REFORM

A new level

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Reform

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Executive summary

The rise of the ersatz A-level has stymied independent study and original thought. After successfully becoming a mass market qualification in the 1980s and 1990s, A-levels underwent radical surgery in 2000 that damaged their intellectual integrity. Modularisation and mechanised marking were introduced despite the objections of universities. These changes have not widened participation – instead they have created a generation of "high maintenance students" who struggle to think for themselves. The A-level should be renewed and expanded by putting universities back in charge, and must be offered at all schools – otherwise the most deprived students will be denied an academic route out of poverty.

Intellectual integrity is not the privilege of an exclusive elite. It is the foundation of a good education. Universities, employers and students all crave the independence of mind developed through in-depth study of a coherent academic discipline, demonstrated by the fact that 46 per cent of 16 year olds now study A-levels compared to 33 per cent doing other qualifications.. The A-level is primarily a university entrance exam – 76 per cent of students who do it go on to university. Yet universities are almost entirely marginalised in the process of setting and validating A-levels.

Reform's study by academics into English, Mathematics, History and Chemistry shows a hollowing of A-levels, particularly since 2000. "Like sat-nav rather than a map" (Mathematics) or "using somebody else's mind" (English), A-levels do not encourage students to think or show flair. Students are heavily directed in answering questions with rigid marking schemes and "assessment objectives" making it clear exactly what is expected of students.

Interviews with admissions tutors reveal a generation of students who struggle to study independently and think for themselves. The idea that only "elite" universities are suffering is a myth. *Reform*'s research into some lower-ranking institutions indicates that their students too are capable of more, but are arriving at university less and less well-prepared.

The key change was the wholesale introduction of modular exams in 2000 which saw the quantity and cost of exams doubling. Modularisation has particularly affected linear subjects like Mathematics that need to build on previous experience. Resits have created a group of students who always seek a "second chance". Mechanised marking has prevented examiners from rewarding clear flows of argument, originality and flair.

Intellectual integrity was traded off against a central drive for wider participation. This has failed. Increases in participation have flagged since the major changes to A-level in 2000, following acceleration in the 1980s and 1990s. If anything the gap between schools in the state and private sectors is widening as the best schools increasingly turn to respected, rigorous qualifications such as the International Baccalaureate and Cambridge Pre-U. Meanwhile the majority of state schools are stuck with a hollower A-level.

Action must be taken to re-link A-levels with their strong academic heritage. Universities should take responsibility for the quality assurance of A-levels. New ersatz qualifications such as "Use of Maths" and "Critical Thinking" A-levels should be halted. The renewed A-level should be available in all schools, giving students from all backgrounds the opportunity to study genuinely thought-provoking material that equips students properly for further study and provides Britain's economy with the sound academic foundation it needs.

1
The A-level: an education in demand

> "Intellectual integrity is not the privilege of an exclusive elite. It is the foundation of a good education."
> **Professor Francis O'Gorman, Head of English, University of Leeds**

A good academic education forms the basis of the most successful elements of Britain's economy. For the past twenty years the A-level's popularity has grown in line with an increased global demand for academic skills. It is the most popular choice for school leavers and the main route to university. Surveys consistently show that the vast majority of the public recognise that the A-level is an important qualification to achieve.[1] Employers and universities value the preparation for independent study and the ability to think and engage with a subject at a deep level.

Academic excellence is highly prized

Economic developments are fuelling an ever increasing need for academic ability.[2] There is demand for a more educated society and a higher level of personal capability.[3] The Leitch Review of Skills projected a 50 per cent increase in the share of highly skilled occupations, such as managers and professionals, and a decrease in low skilled occupations, by 2020.[4] The real value of academic excellence is shown by the Government's immigration points system, which places a very high value on master's degrees, PhDs and other academic qualifications above their vocational rivals.[5]

Employers want the ability to think

In the modern economy employers need school leavers to have developed the ability to think and reason beyond basic literacy and numeracy. Businesses are placing greater emphasis on capabilities of the mind onto which they can add specialist training.[6] Professions such as nursing also require the adaptive, critical and problem-solving skills that academic training can deliver. Vocational skills can be developed on the job; it is the academic grounding that needs to be in place.

Despite the impact of the recession on graduate recruitment, modern economies will have to continue to expand participation in higher education.[7] Britain will need more graduates, not fewer; the earnings premium for graduates has held up despite increasing numbers.[8] The academic route remains by far the most successful path for school leavers to follow. The returns are considerable: a graduate earns £408,000 more over a lifetime than someone with no skills.[9]

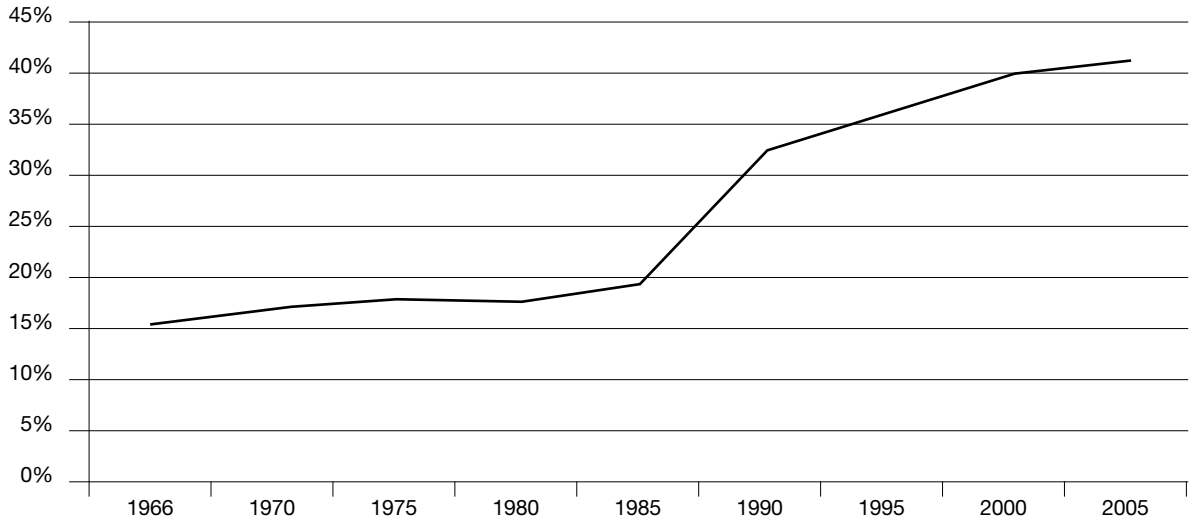
Increased interest in participation from students

The A-level has become the accepted path for most school leavers. At 16, 46 per cent choose A-levels whereas 33 per cent choose other qualifications.[10] Now around 40 per cent of school leavers sit an A-level examination, double the proportion of the mid-1980s.[11] More students recognise the advantage of further academic education and the chance to focus on a specialist discipline post-16. Students value the A-level as an opportunity to study independently and to become immersed in their chosen subjects. It is right that in the modern mobile economy a substantial number are following an academic route and studying A-levels.

1 For example, Ipsos MORI (2009), *Perceptions of A Levels and GCSEs*.
2 Barro, R. (2001), "Human capital and growth", *The American Economic Review,* Vol. 91 No.2.
3 Haldenby, A. et al. (2008), *The mobile economy*, *Reform*.
4 Leitch, S. (2006), *Prosperity for all in the global economy – world class skills*.
5 UK Border Agency (2009), www.ukba.homeoffice.gov.uk.
6 CBI (2007), *Shaping up for the future: The business vision for education and skills*.
7 Haldenby, A. et al. (2008), *The mobile economy*, *Reform*.
8 Walker, I. and Zhu, Y. (2008), "The college wage premium and the expansion of higher education in the UK", *Scandinavian Journal of Economics*, Vol. 110 No. 4.
9 Based on data collected from Office for National Statistics (2007), *Annual Survey of Hours and Earnings*, Table 1.1a and Office for National Statistics (2008), *Labour Markets Statistics*, Table 2.
10 DCSF (2009), *Participation in Education, Training and Employment by 16-18 year olds in England*.
11 HMSO (1966-1995), *Statistics of Education Vol. 2: School Leavers.*

A mass-market product for university entry

Figure 1: Percentage of school leavers taking A-level examinations
Source: HMSO (1966-1995), *Statistics of Education*; DCSF (2009), *Participation in Education, Training and Employment by 16-18 year olds in England* [12]



A-levels' primary function is as preparation for university. In recent years between 74 and 78 per cent of 19 year olds with achievements at A-level entered higher education.[13] The proportion of A-level students progressing to university has risen dramatically in the past 20 years; in 1985 less than 50 per cent of students with A-level passes went on to read degrees.[14]

Traditionally the sixth form has gradually introduced students to the rigorous academic study that they can expect at university. Students are encouraged to focus on their chosen subject before progressing to read a degree in their chosen discipline. Studying A-levels should serve to develop a student's capacity for independent learning, critical thinking and gaining an in-depth understanding of a subject.

The value of A-level – immersion in the subject

Academic, subject-specialised study at university demonstrates that the way to develop logical and critical thinking is to study a rigorous subject in depth. A more rigorous A-level based on subject specialisation, independent study and critical and original thinking would ensure that students can successfully progress onto university. Alternatives such as the International Baccalaureate (IB) do not necessarily provide a more effective preparation for university. The broad curriculum and assessment of the IB diploma, comprised of courses chosen from six subject groups, an extended essay, a module in theory of knowledge and participation in creative arts or sports, does not provide an adult style of education.[15]

12 1966-1985: number of school leavers who took A-levels as a proportion of the number of school leavers; 1985-2005: number of 18 year olds who took A-levels as a proportion of 18 year olds.
13 Department for Children, Schools and Families (2009), *Youth Cohort Survey*.
14 HMSO (1985), *Statistics of Education Vol. 2: School Leavers*.
15 International Baccalaureate (2009), www.ibo.org.

The role of academic education in social mobility

For decades academic achievement has driven social mobility. The expansion of school education in the first half of the 20th century drove the development of meritocracy in Britain. With graduates earning 77 per cent more than non-graduates, access to higher education remains critically important for the life chances of young people from deprived backgrounds.[16] Socially mobile societies are the ones where individuals are empowered and encouraged to develop their own capability, gaining the soft skills that will be vital in the future job market.[17] The academic route is still the most effective way for young people to reach a more secure and rewarding place in society.

Emulating the A-level

British governments often fail to acknowledge the value of the A-level. But other countries use the A-level or design their own similar qualifications. In Singapore, for example, the Cambridge International A-level is the state qualification.[18] A-levels remain popular across the Commonwealth, while the International A-level is a well-regarded examination providing preparation for university education for students in 125 countries.[19]

16 OECD (2007), *Education at a Glance 2007.*
17 Bosanquet, N. et al. (2008), *Shifting the unequal state: From public apathy to personal capability*, *Reform*.
18 University of Cambridge International Examinations (2008), *Cambridge International A and AS Levels*.
19 University of Cambridge International Examinations (2009), cie.org.uk.

2
A hollow preparation

The political debate about A-levels has focused on worries about whether today's students are studying comparable content with those of the past. *Reform*'s research suggests that debates purely about content obscure a wider issue about how – rather than what – exams are encouraging people to be taught. It is certainly true that the content of some subjects – particularly Mathematics – has diminished. However even subjects that retain much of the superficial content (such as English and History) have seen a hollowing out in the extent to which they are understood and explored. Academics across the university sector suggest that the primary problem is the way that A-level questions and answers are encouraging teachers to teach and students to think.

Reform interviewed academics, including heads of department and admissions tutors from a range of universities, to establish how well A-levels prepare students for further study.[20] This indicated that the problems are not, as is generally believed, limited to the elite universities. Instead, the prescriptive and uninspiring nature of some A-levels is letting down universities from Oxford to Greenwich.

The most popular A-levels

A total of 256,622 16-18 year olds took A-levels in 2008 – taking 741,351 papers.[21]

Figure 2: Most popular GCE A-level subjects for students aged 16-18 years old (2007/08)
Source: Department for Children, Schools and Families (2008), *GCE/VCE/Applied and Equivalent Examination Results in England 2007/08*

Subject	Entries	Percentage of candidates
English	80,917	32
Mathematics	57,618	23
General Studies	57,086	22
Psychology	49,434	19
Biological Sciences	48,397	19
History	42,107	16
Art and Design	39,623	15
Chemistry	36,328	14
Business Studies	29,887	12
Geography	27,846	11

Taking the thought out

Reform asked a team of academics in four of the top ten A-level subjects – English, History, Chemistry and Mathematics – to analyse A-level exam papers.[22] None of these academics are involved in the setting or marking of A-levels; they have analysed question papers and marking schemes in terms of their ability to prepare students for university. Each analysis is based on the examination papers for the years 1951 to 2008 and the marking schemes and examiners' reports where available.

20 *Reform* interviewed several academics from each of the following universities – Oxford, Cambridge, UCL, Imperial, LSE, Leeds, Birmingham, Greenwich, East London, London South Bank, Queen Mary, Sheffield, Warwick and Kent – in the following departments – English, History, Chemistry, Mathematics, Sociology and Media Studies.
21 Department for Children, Schools and Families (2008), *GCE/VCE/Applied and Equivalent Examination Results in England 2007/08.*
22 Exam papers courtesy of Cambridge Assessment Archives Service.

The findings suggest that all subjects have much more heavily directed questions and marking. The frequency of tests is preventing the study of off-syllabus material. Exams allow candidates less scope for using their own mind, thinking through problems and expressing originality. Subject content is questionable or inappropriate in some areas due to a lack of university input. Marking schemes have become more specific to the extent that examiners' judgement is no longer considered to be necessary or even desirable. However there are noticeable improvements in students' presentational skills.

English and Mathematics are the most heavily affected

Reform's study indicated that these changes have had a more dramatic impact in English and Mathematics than in History and Chemistry. This is worrying as English and Mathematics are the two most popular A-levels and form the heart of learning in the arts and sciences. The reasons given below by academics suggest that the higher empirical content in History and Chemistry may render them less affected by a modular course. In English and Mathematics a more holistic view is required by the student who must formulate a critical response or solve a given problem.

English A-level: 1951 to 2008

Professor Francis O'Gorman, Head of English, University of Leeds

The purpose of English A-level for universities

English literature as a university discipline has changed its identity remarkably. A-level papers from 1950 to the present day naturally offer a window onto the broader changes in the discipline's identity. To comment on these changes is not necessarily to make any value judgement. Exam papers at school level reflect changes as, more obliquely, they help shape the discipline. Written by graduates of the universities, referring to curricula taught by graduates of the same universities, they are the gateway for others wanting to graduate. Changes in the university conception of what English is, take, accordingly, a long time to establish themselves throughout the whole pedagogical and scholarly system.

The shape, not the level, is the problem

But, bearing the larger shifts in the discipline in mind, can anything be said about standards in the 60 years of A-level questions? About the kinds of teaching that exam papers require and, in their own ways, do themselves? Exam questions are never innocent things. The principles and assumptions behind them are suggestive indicators of the principles and assumptions behind an educational system. To be sure, there is much to admire in the 2008 examinations for English literature. There are challenging questions, a variety of approaches to literature and plenty of opportunities for a good student to shine, assuming that they can do so in the terms the marking scheme recognises. The requirement to read more widely and "off the syllabus", the varieties of assessment, and the wide range of themes and texts are all encouraging. But there are difficulties too. The difficulties primarily concern not the level of analysis that is being required, but the shape of it. English literature is an analytical subject. It asks for argued, reasoned views about challenging forms of imaginative writing. And it asks for people to think about those texts themselves. These are fundamental principles, and they matter at A-level as much as anywhere else.

Less room for manoeuvre

We are not looking back to a golden age. But contemporary questions have moved away from their predecessors in important and difficult ways. Most obvious is the restrictions placed by those exam questions on what the students can write. The central issue here is the way in which the questions that students are taught to answer curtail by definition individual thought: they impede the analytical, independent thinking they should be fostering. This is a challenging feature, at odds with the analytical rigour and independence of thought the subject is about. Here is a typical question from 1951: "'The pattern of *Richard III*, with the rise and fall of the hero, helps to make it a powerful, even tragic play.' How far do you agree?" Whether asking a candidate to try to define "powerful" or "tragic" in order to make rigorous sense of this question is not, here, the point. It was up to the candidate to respond in the best way he or she thought appropriate. That, indeed, was part of what was being assessed.

Using someone else's mind

But in the OCR papers for June 2008 – not untypically – candidates do not have the same freedom to use their own minds. Every question on the Poetry and Prose paper offers a structure, for instance, a guide in the form of instructions beginning "In the course of your answer..." There is a template for what is expected from a successful answer. So, for example:

OCR May 2008
Poetry and Prose (Open Text)

3b) Considering in detail **one or two** poems or passages from longer poems discuss Byron's exploration of the experience of exile.

In the course of your answer:
- look closely at the effects of imagery, language and verse form in the example(s) you have chosen;
- comment on ways in which your example(s) relate(s) to the methods and concerns of other poems by Byron.

..... [30]

Candidates are given a general shape, and general steers. What is being assessed is not simply how they handle the question, but how they handle the guide to how to handle the question. Consider, similarly, this question from the Shakespeare paper:

OCR May 2008
Drama: Shakespeare (Closed Text)

Question

1 Read the following passage from Act 2, Scene 1. How does it contribute to your view of Falstaff in *Henry IV (Part 2)*?

In the course of your answer:
- look closely at the language, imagery and tone of the passage;
- comment on what the passage suggests about particular aspects of Falstaff's character in the play.

..... [30]

Restrictions

Perhaps these directions are not specific enough to be all that restrictive. But they set limits, nevertheless. And their implications are difficult too. For they imply that there is a predetermined shape behind the best answers; that there is a frame that must be adopted for success. Together with a positive marking scheme – the reward of marks for specific things said, regardless of what else is said or in what way – these requirements suggest candidates must work to the expectations of someone else's mind. For those in universities and beyond endeavouring to teach students how to reason and argue for themselves, it is hard to un-teach the assumption that there are formulaic ways of answering what you are asked, that there is a required shape and general content to an answer which has already been determined by another. Candidates who have excellent ideas that cannot be fitted into these limits are, it seems, thwarted. And that is a cap on success.

Generalisation

Earlier examination papers encourage generalising. They were keen on evaluation (an example question from 1970 being: "Do you agree that Shylock disturbs the artistic unity of *The Merchant of Venice*?") and they tempted candidates to write in huge generalisations about the so-called universal "human nature". Contemporary exams still expect evaluations of some kind or other, and invite belief in universals. Although few university English departments would be keen to sign up either to agreed principles of evaluations or of universals, these are perpetual and tricky issues which A-level students should not be expected to solve. But what is new in recent papers is another set of problems about how to argue. Some 2008 examination papers obliged candidates to make arguments that their knowledge could not even begin to support about literary history. If encouraging enormous generalisations is a regrettable feature of examination papers as a genre (at school or university), 2008 English literature A-level questions were peculiarly risky. "By comparing *Tender is the Night*", runs a typical question on OCR's 2008 Comparative and Contextual Study paper, "with at least one other appropriate text, consider how far you agree with the view that 20th century American prose explores a sense of being cut off from the past". The problem here is the false position the candidate is put in. The question – and there are others that require similar generalisations – is not the more reasonable "how far do you agree that the two texts explore a sense of being cut off..." but how far 20th century American prose does. The idea of being judicious with evidence and rigorous in conclusions can be grasped only with difficulty through questions that invite candidates to be neither.

The foundation of a good education

It is hard to exaggerate the importance of framing questions well. Candidates are taught in their time at school towards success in answering those questions: they shape the nature of their education. The 2008 A-level English literature exam papers cause problems because, in key areas, they create a challenge to intellectual integrity. That matters – and university English departments struggle to undo the damage. Such integrity is not the privilege of an exclusive elite. It is the foundation of a good education. A-level exam questions in English literature need to encourage proper, independent, self-critical argument within the bounds of what is reasonable to expect at the age of 18. When the questions look as if they may be seeking something other than that, it is a matter in which we should all interest ourselves.

Mathematics A-level: 1951 to 2008

R. A. Bailey, Professor of Statistics, Queen Mary, University of London

From roadmap to sat-nav

The most important change in exams over the period 1951-2008 is that sitting a Mathematics A-level paper now is more like using a sat-nav system than reading a map. If you read a map to get from A to B, you remember the route and learn about other things on the way. If you use a sat-nav you do neither of those things. The questions in the 2008 paper are heavily structured in this way and the result is that students will retain very little knowledge and develop very little understanding.

Questions have evolved over the decades. In 1951 there were almost exclusively single questions; by 1970 most questions were split into numbered sub-parts, with part-marks shown. In 1990 this process went a lot further. Each question was very short, so that the candidates had to keep changing topics. Also, the ratio of words to formulae became much smaller. But by this stage not all papers had been balkanised like this and there was little change from 1990 to 2000.

However the questions were further subdivided and directed by 2008 where there was a change from two substantial three-hour papers to a modular system with several 90-minute papers. The questions became orders: do this, do that. They include hints and instructions about which method to use. The questions on the Core (Pure Mathematics) papers are mind-numbingly boring, apart from those that are mind-numbingly stupid. Consider the Core question 7, part (ii), below. In our country, plants reproduce annually. Calculating that there will be 100 plants in 11.3 years from now is just silly. Part of learning about the interplay between Mathematics and real-world problems is learning about what sort of models make sense, and what sort of accuracy is appropriate. In this application, it does not make sense to give the number of years to "three significant figures" if that is not an integer.

OCR June 2008
Core Mathematics 3

7. It is claimed that the number of plants of a certain species in a particular locality is doubling every 9 years. The number of plants now is 42. The number of plants is treated as a continuous variable and is denoted by N. The number of years from now is denoted by t.

   i) Two equivalent expressions giving N in terms of t are $N = A \times 2^{kt}$ and $N = Ae^{mt}$.

   Determine the value of each of the constants A, k and m. [4]

   ii) Find the value of t for which $N = 100$, giving your answer correct to 3 significant figures. [2]

   iii) Find the rate at which the number of plants will be increasing at a time 35 years from now. [3]

Mechanics 1 is less boring but still an ordered list of small tasks. Question 5, below, does not make physical sense. It is possible that the wagons become glued together, giving rise to the scenario in part (i). Otherwise, you need to know about elasticity to calculate the velocities after the collision. Saying "let them be equal and opposite" is not good physics, and it is not possible for all values of the two masses and two initial velocities. Part (ii) is just giving students a bogus equation to solve, just for the sake of solving an equation. Probability and Statistics 1, however, is a good exam.

OCR June 2008
Mechanics 1

5. A railway wagon A of mass 400 kg and moving with speed 5 m s^{-1} collides with railway wagon B which has mass 3600 kg and is moving towards A with speed 3 m s^{-1}. Immediately after the collision the speeds of A and B are equal.

   i) Given that the two wagons are moving in the same direction after the collision, find their common speed. State which wagon has changed its direction of motion. [5]

   ii) Given instead that A and B are moving with equal speeds in opposite directions after the collision, calculate
   a) the speed of the wagons,
   b) the change in the momentum of A as a result of the collision. [5]

Compartmentalised not holistic

Another important change is that now there is a wide choice of topics to study for A-level Mathematics. Given that Mathematics is a cumulative subject, with each topic depending on several previous steps, any topic that is studied by some A-level students, but not all, must be re-taught to all of them in their first year at university. The amount of choice in this selection of modules presents a headache for universities. Any topic which is not a compulsory part of A-level has to be taught to all first-year undergraduates, because later topics depend on them.

The 2000 syllabus contained the following laudable statement: "It should be noted that individual questions may involve more than one section of the following list and that topics may be tested in the context of solving problems and in the applications of mathematics." It is questionable whether that is still true. We expect our students to take a holistic approach to the subject, but it seems from these A-level questions that they expect it to be compartmentalised.

Content downgraded and lack of understanding

Considering the content in the syllabuses from 1952, 1960, 1980, 1990 and 2000, the obvious changes are the removal of geometry, both practical and theoretical, and the gradual decreasing importance of proof.

There are questions which seem to have been set by people who do not understand the subject. There are some supposedly applied Mathematics questions where either the question or the answer does not make sense in the real world. There are some statistics questions whose basis will encourage bad practice in statistics in later life, whether as a mathematician, a scientist or a policy maker.

Critical thinking and reasoning

The AQA specification for 2010 does not bode well. Under "Key Skills" it says that "the study of mathematics does not easily lend itself to developing the key skill of problem solving". On the contrary, problem solving is one half of Mathematics, the other being logical argument and proof. When you have solved a number of similar problems then you develop a mathematical theory about them. This problem-solving ability is one of the main skills that has been lost from school Mathematics.

From discovery to contract

The syllabus changes suggest a new approach to marking. The 1952 syllabus is written in normal text, in paragraphs; by 2008, we have a numbered list, with very precise details as well as "curriculum objectives". From 1952 to 1980, and maybe even until 1990, the syllabus suggests that the examiners intend to find out if the candidates know any Mathematics; in 2000, the syllabus seems more like a contract: you do exactly this, this and this and then we will reward you. On the surface, that approach looks fairer, but it cannot promote genuine learning.

Examiners not trusted

The model answers and mark scheme for the 2000 papers are problematic (for example, "y depends on x" is explicitly allowed but "x affects y" is explicitly forbidden). The mark scheme is rigidly broken down into single marks. One cannot avoid the suspicion that the main reason for the change to the "sat-nav" type of question is to enable consistent marking from people who may not be trusted to actually understand the Mathematics.

History A-level: 1951 to 2008

Ian Moxon, Lecturer in History, University of Leeds

From 1951 until 2000 inclusive the Cambridge A-level examinations in History followed a fairly uniform pattern. A range of papers was set, between 10 and 20 in number, covering the past from antiquity to the 20th century, each asking questions mainly about the history of the western world (England, Europe, the USA, world affairs) in one of several specifically-defined time spans. Conventionally each pupil would take two papers, selected from groupings of papers designed to ensure that, in addition to the history of England, the history of some other part of the world would be studied.

History: an enquiry

The History syllabus and examination determined the nature of History teaching in England's secondary schools. History was still enquiry, the form in which it had been defined for the western world by Herodotus in the fifth century B.C. The bulk of the content of each of the papers consisted of propositions expressed as questions inviting investigation, discussion and assessment of the propositions. The one concession evident in the examination papers to the overt assessment of the working methods applied by the historian was the generally compulsory document-based question at the start of each paper. In general, however, the syllabuses said comparatively little about pedagogic methods. The business of the examining board was assessment, from a university perspective, of the achievements of pupils prepared by the schools. The character and content of those pedagogic methods were the concern of the schools and the teachers.

Use of knowledge

The examiners concentrated on the setting of questions by means of which the candidates might be well assessed and differentiated from one another. In distinguishing the A-level History examinations from the O-level ones set in 1960, the writer of the report said of the A-level papers that "the examiner must set questions which will force candidates to use their knowledge, not merely to display it". It was hoped that candidates would display good judgement and a measure of originality. These criteria may be summarised as seeking the demonstration of individual critical and constructive ability. But application of these criteria was open-minded and flexible: the examiner was not in the business at all of laying down, whether in a marking scheme or in his own head, a definite pattern to which the answer to any question must conform.

A new purpose

Examinations set under the unit-based or modular system which has prevailed since 2001 possess aims and objectives quite radically different from those defined above. It acknowledges that not all those who take History at school will necessarily wish to study it at university. The experience of studying History at school must therefore be rendered a worthwhile activity in its own right, not merely a means to an end perhaps never to be pursued. So too the A-level syllabus and assessment must no longer be merely a stepping-stone or bridge for access to an institution of higher education. The examination should be much more closely integrated with the teaching methods and the teaching methods must be much more explicit about their aims and objectives.

End to mystique

Previously the principal requirement for the achievement of success in the study of A-level History had been the application of a candidate's intelligence and critical abilities, sharpened by a limited amount of guidance and practice. Now the emphasis is on the practical techniques for studying the past, all of which could be acquired. No longer was there a mystique: anyone could do it provided that they were equipped with the right skills. The study of History has thus become the application of a set of techniques specifically inculcated in stages in schools and systematically assessed at intervals by examination. Everything is specified and everything is determined. Now the syllabus requires not merely two three-hour examinations taken at the end of the course but a programme of assessment consisting of six components spread over two years, by means of which several of the skills required for historical study were to be acquired and developed.

Based on students' capabilities not on expectations

Until the examination diet of Curriculum 2000 the model had been top-down. The expectations of what a first-year undergraduate might be expected to know and be able to do determined the format of the A-level examination. Everyone, even those who had no aspiration to study History at university, was measured against that demanding standard, which acknowledged that there were few certainties about the past and that creative imagination combined with rigorous familiarity with the evidence was the pathway to understanding. After 2000 the A-level examinations, by now increasingly designed and set by those involved directly in the teaching of the syllabus, cater to the interests of a wider audience by providing an A-level which was no longer only, or perhaps any longer actually, a stepping-stone to the next stage of a specialised higher education.

Chemistry A-level: 1951 to 2008

Compiled by Dr Dewi Lewis, Chemistry Admissions Tutor, University College London in discussion with numerous colleagues and teacher

Assess everything, revise and forget

A key difference between A-level Chemistry exams before and after 2000 is a greater emphasis on frequent assessment with shorter exams and a dramatic increase in total assessment time. The breadth of assessment has also increased; everything has to be covered by some assessment. Frequent assessment favours the "shallow learner": revise and forget, so students who would have failed horribly in 1950 could well achieve a good mark. Those who have ability would do well under either system.

Rigid papers that lead through the subject

Older papers favoured those who knew immediately how to do questions and penalised those who could not get started. Average candidates were poor at this and avoided the hardest questions, but even the brightest opted for recall questions according to exam reports. Moreover, older papers, by being less prescriptive, led to excess verbosity and poor layout of solutions. Students were given less guidance as to how to go about answering the questions and so this required good understanding, knowledge, writing and exam skills if they wanted to do very well.

In modern questions the scientific knowledge required to answer the questions thoroughly is similar but the questions are presented in a more approachable way that may make them more straightforward to answer. Since the 1970s the structure of the questions started changing in that the questions were broken up into sections. Candidates are led through the exam in a sort of "quiz" or puzzle style, with lots of opportunities to jog their memory that were not available to earlier candidates.

Elegance and discretion

In the past there were more opportunities for elegant solutions: but perhaps less often seen than thought. Examiners had more discretion to decide if something deserved a mark even though it was not necessarily specified in a mark scheme. For example, in the 2008 mark scheme one question gives 2 marks for the correct answer but the student loses a mark through sloppy presentation. But 2 marks can be given to an ambiguous answer. The marker is not allowed to give an opinion.

Content

The breadth of knowledge is greater in later papers but the depth is marginally less. Some topics are no longer taught to make room for new topics that have been included to keep up to date with current trends and development in the subject (e.g. spectroscopy). Phase diagrams have disappeared, which were a fantastic preparation for university Chemistry and other subjects: but are also not included in the "more rigorous" IB and Pre-U. Much is made of the lack of numeracy of students, but we introduced a "remedial maths" course for chemists in 1965 not 1995!

More compulsory, fewer optional questions

Although some calculations in the earlier papers were more demanding, the students could choose not to do them (and according to exam reports many did avoid them). Now there are a number of calculative questions of varying difficulty but they all have to be attempted. More of the older papers could be done by recall and question spotting. For instance, in the 1960 organic Chemistry examination, students needed to have knowledge of about 10 different transformations. Of these six would be asked in the exam every year. Twenty per cent of a 1980s syllabus could be ignored on teacher advice as it rarely came up or you did not have to answer it. In six exam papers now (not two) you cannot avoid anything. So whilst the knowledge may be retained for shorter time it has to be there on exam day.

Better context but less concept

There is now a greater emphasis on context than in older A-level exams. The way the topics have been grouped into courses such as chains and rings and the way they are contextualised into "hot topics" such as green Chemistry is a positive development. The breadth of the topics covered and the frequency of their

examination means that the depth of conceptual understanding is less. But good students are now much more capable of discussing their science and presenting it. We have an exam now where mediocre students can get an A by being trained but in the past good students could excel in the now defunct "S-level", whilst often doing comparatively poorly in the A-level.

Practical and presentation skills

The practical exam is more structured today, with the mark scheme being more rigid and the teacher's input lessened. From our perspective, students do less but this is very dependent on the school and teacher. Now everyone has to perform set pieces. In the past if you had a brilliant practical teacher you were also brilliant at it. When it comes to communication skills, modern students, from day one are able to distil and convey science in the form of talks and posters and discuss material with an academic far better than in the past.

A way forward in Chemistry

We recommend deeper and fewer assessments and that marks from resit exams take precedence. To test the gifted, we should give them practical investigations to do, make them conduct book research and write essays but do not fill the syllabus with now irrelevant material from a previous age. We should also encourage students to use non-exam board specific textbooks; this is the easiest way of making a "student read outside the syllabus".

Inadequate preparation for all abilities

In research interviews with academics, from both the most highly-rated research universities and teaching universities at the lower end of the league tables, *Reform* found many common themes in discussing A-levels and readiness for further study. Universities have to engage in "remedial education" to compensate for the defects in school education.[23] One lecturer at Imperial College London suggested that three A grades is no longer a guarantee that students have adequate basic skills.[24] Many commented that there was "ignorance" of what went on in schools and a "disconnection".

Independent thinking

Students' lack of ability to think independently was widely remarked on in *Reform*'s interviews with academics. One English lecturer said that students "don't welcome opportunities for independent study" or "curiosity-led learning". She noted that while students may possess subject knowledge they are incapable of making comparisons and drawing out themes.

Unfavourable comparisons were drawn between A-levels and qualifications held by mature students. One History academic noted the difference between students who had studied for an access course – and were well-prepared for higher education – and A-level students who had been "spoon fed" and had to learn how to "learn independently". She attributed this directly to students being taught to pass exams instead of to "grapple with ideas". Courses were "too exam-driven" in her opinion; it was "very difficult to get students to think outside the box".

One English academic remarked that undergraduates spend their first year "floundering". A Chemistry academic identified significant problems with basic note-taking. But this does not mean that there should be a focus on "functional skills" that prepare students for life. One History academic flagged up a clear tension between the skills required for academic study and the Government's education policy focused on achieving economic and social objectives.

Declining basic skills

Concern was noted in all subjects about levels of basic literacy and numeracy. One English tutor complained that the "basic protocol of preparing written work is very weak". She identified an inability to reference, spell and structure paragraphs. Since 1993 a gradual but significant drop in what is an acceptable standard of English has occurred. A Chemistry lecturer noted that students were "much better" prepared 15 years ago. He remarked on the substantial amount of work that was required to get first-year students to an acceptable basic standard of mathematical ability. The recurring theme was that across all subjects and ability levels, students were unable to properly write, structure arguments and think critically and logically.

23 The Higher Education Academy (2008), *Understanding Student Needs through Addressing the Knowledge Gap of Academic Staff Regarding University Pre-Entry Qualifications and Student Learning; The Times* (2008), "Education in English schools is 'fatally distorted' says Niall Ferguson", 12 May: "I can think of few worst preparations for Harvard than a typical English secondary education".
24 *The Daily Telegraph* (2008), "University introduces four-year degrees for weaker students", 12 June.

3
An ersatz education

The key finding of Chapter 2 is that the ability of A-level candidates to think intelligently and across their subject has diminished, particularly in English and Mathematics. Several specific changes in the nature of A-levels are the cause of this. These have turned the qualification into a series of limited and discrete challenges rather than an overall analysis of a subject. The result is the creation of qualifications that have the same superficial contents but an ersatz version of deep academic study.

Modularisation – introducing incoherence

The modularisation of A-levels started in the 1990s. The first modular A-level was introduced in 1991, but before 1996 only 2 per cent of A-levels were modular. This increased to one-fifth in 1996 and 50 per cent in 1998.[25] The introduction of Curriculum 2000, in that year, divided all A-levels into six modules.[26] This was despite a 1999 Ofsted report which criticised modular examinations for breaking up the coherence of a course and limiting the ability of teachers to ensure a thorough understanding of the subject.[27] A report by the University of Newcastle found that candidates with average GCSE results could expect to gain a grade C at A-level on a modular course, compared to a grade D on a conventional course.[28] David West, then head of Ofsted's post-16 division, said that "sometimes links between modules are lost because they are taught by different teachers. The modular approach can also constrain teachers in the way they teach the subject."[29]

This compartmentalisation is a particular concern for subjects such as Mathematics which are of a hierarchical nature and rely on building blocks at each level to facilitate advancement.[30] As one teacher said to *Reform*, "modularisation makes it impossible not to teach to the test", since it denies teachers and students both the time and the incentive to cover material beyond the core curriculum.

The problems with modularisation have become sufficiently great that most A-levels are now being reformed to consist of only four modules, rather than the current six.[31] However, although this change is an acknowledgement of the problem, it does not solve it.

Resits

With the introduction of modular A-levels in Curriculum 2000 students gained the ability to resit particular units throughout the two year course. Students are now routinely entered for exams in January on the assumption that they will resit them in the summer to achieve a better result.

The ability to resit reinforces the mindset that success at A-level is actually about a narrow achievement in six separate mini-courses. *Reform*'s interviews with academics have revealed that this has created a reliance on resits amongst undergraduates: many students expect to be able to retake exams in which they feel they have underperformed.

Cost

The changes introduced with Curriculum 2000 – not the rise in student numbers – led to the explosion in the number of individual A-level examinations as shown in Figure 3. This has driven up the cost of A-levels dramatically but the proliferation of assessments has not maintained quality.

25 *Times Educational Supplement* (1997), "Traditional courses on the way out", 15 August.
26 Qualifications and Curriculum Authority (2009), www.qca.org.uk.
27 Ofsted (1999), Modular GCE AS and A-level examinations 1996-1998.
28 *Times Educational Supplement* (1995), "Leaked report fuels A-level fears", 20 January.
29 *Times Educational Supplement* (1999), "Arts at risk in A-level reform", 14 May.
30 Kounine, L. et al. (2008), *The value of mathematics*, *Reform*.
31 Department for Children, Schools and Families (2009), www.dcsf.gov.uk

Figure 3: The rising number of A/AS-level assessments since 1960
Source: DCSF and examination board data; *Reform* calculations

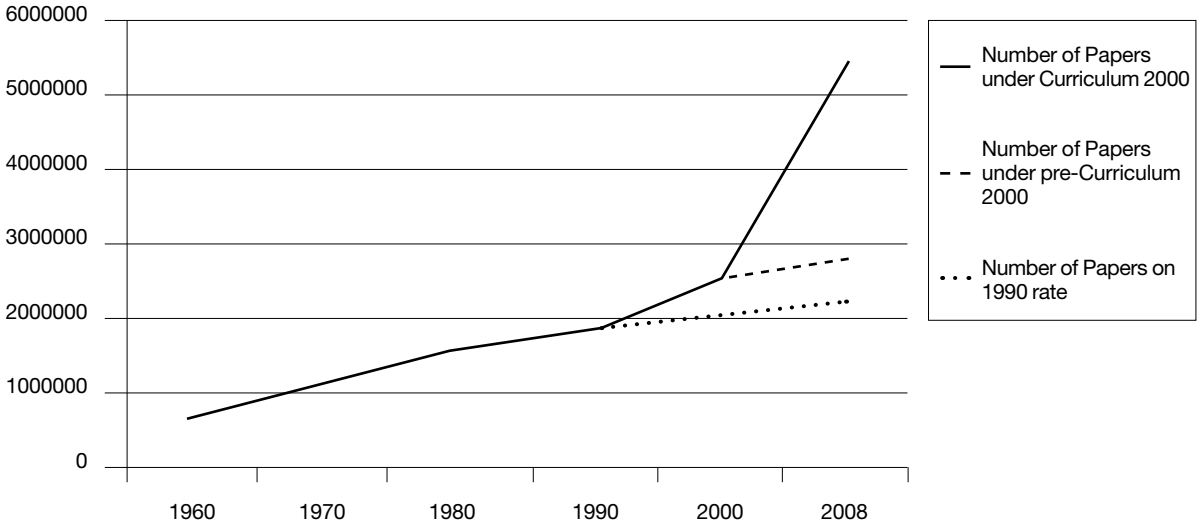


Figure 4: Estimated number of papers and total cost for A/AS Level examinations from 1970[32]
Source: Department for Children, Schools and Families; examination board data; *Reform* calculations

	Candidates	Entries	Papers	Cost
1970	103,000	441,898	643,750	£9,217,992
1990	185,100	615,725	1,388,250	£18,878,128
2000	231,351	672,518	2,168,916	£30,532,317
2008	256,622	741,356	5,455,655	£70,693,952

Mechanised marking

As explained in Chapter 2, students are now examined for meeting prescriptive criteria and reproducing what the examiner is looking for, not for demonstrating a high level of skills. There is now nothing to be gained in looking beyond the checklist of assessment objectives, or indeed thinking originally. Markers' judgement is no longer considered necessary or even desirable: as discussed in Chapter 2 the opportunity for examiners to reward original, elegant or exceptional answers has been vastly curtailed.[33] This is particularly damaging in a subject like English which relies on an individual critical response.

32 Adjusted for inflation.
33 *The Guardian* (2005), "It really is that bad", 25 August.

The National Qualifications Framework

The confusion about the role of the A-level is evident in the wider conflation of academic and vocational disciplines. Successive governments have sought to address Britain's skills shortage by designing vocational qualifications such as the National Vocational Qualification (NVQ) and the BTEC. However, these qualifications have failed to revive the skills economy or replace well-regarded business-led awards.[34] Moreover, the attempt to combine theoretical teaching and practical skills has undermined the value of these qualifications for businesses.

The National Qualifications Framework (NQF) was created to simplify a diverse market of qualifications and break down the distinction between vocational and academic education, and now prevents people from making informed choices about the value of the education they are receiving. Through grouping qualifications together in arbitrary "levels", the framework reduces all achievement and ability to a number. With different qualities of education represented as an undifferentiated quantity, the NQF is a central driver blurring the boundary between academic and vocational education.[35]

Conflating academic and vocational curricula has crippled the ability of these qualifications to serve their primary purpose. The result is pseudo-academic vocational courses that do not teach practical skills and pseudo-vocational academic courses that does not require depth of thinking or rigour. Successive governments have sought to make the A-level more varied, broader and more inclusive of vocational requirements. One intended effect of the introduction of the AS-level was to make it easier for more students to undertake a vocational option.[36] As discussed below these objectives are most evident in the new Diploma.

Applied and vocational skills are useful and important. Many school leavers have opted for a vocational route, with the number of 16-year olds taking NVQs or equivalents increasing from 13 to 27 per cent between 2001 and 2007.[37] However research by the Centre for Economic Performance has shown that the economic return from these qualifications is marginal.[38] The evidence suggests that these courses are best delivered by employers and professional bodies.[39]

"Use of Maths": a pseudo-qualification

As shown in Chapter 2, Mathematics has perhaps suffered most greatly from the changes to A-levels. It is now set to be subject to further change. The QCA is currently consulting on new criteria for the suite of A-level Mathematics qualifications.[40] This consultation, which ends in July, is for new curricula to be taught from 2011 and 2012.

A desire to increase participation in A-level Mathematics has led to the introduction of the Use of Maths A-level as part of this consultation. This new course focuses on using other subjects to teach about Mathematics in context rather than teaching Mathematics itself. The proposed A-level relies on written exams based on data sheets and contexts delivered to the pupil 14 days before the exam, as well as teacher-assessed portfolio work marked across three themes: "structuring and presenting work", "using appropriate mathematics" and "working accurately and interpreting mathematics".[41] Use of Maths will encompass existing Free Standing Mathematics Qualifications (FSMQs), which offer a more targeted and appropriate method to address the decline of higher skills among school leavers.[42]

34 Costello, M. et al. (2006), *Perceptions and Uses of NVQs: A Survey of Employers in England*, Department for Education and Skills.
35 Qualifications and Curriculum Authority (2006), *The National Qualifications Framework*.
36 Qualifications and Curriculum Authority (2009), www.qca.org.uk
37 Department for Children, Schools and Families (2008), *Participation in Education, Training and Employment by 16-18 Year Olds in England: 2006 and 2007*; Department for Children, Schools and Families (2004), *Participation in Education, Training and Employment by 16-18 Year Olds in England: 2002 and 2003*.
38 Centre for Economic Performance (2004), *The Impact of Vocational Qualifications on the Labour Market Outcomes of Low-Achieving School-Leavers*.
39 Haldenby, A. et al. (2008), *The mobile economy*, *Reform*.
40 Qualifications and Curriculum Authority (2009), www.qca.org.uk.
41 Qualifications and Curriculum Authority (2009), *AS/A level subject criteria for use of mathematics: QCA consultation draft*.
42 Nuffield Foundation Curriculum Centre (2009), fsmq.org. FSMQs were introduced at the same time as Curriculum 2000 and suggest an alternative path to assist students gain a deeper understanding of specific areas of mathematics. Currently options include "working with algebraic and graphical techniques" and "modelling with calculus".

Ersatz solutions

In order to target the deficiencies of the current A-level system, such as a lack of critical thinking and an inability to structure arguments, new qualifications have been introduced which attempt to plug the gaps, rather than addressing the heart of the problem within subject teaching and assessment.

"Critical Thinking" A-level

The AS-level in Critical Thinking was introduced in 2000 and is now being offered as a full A-level.[43] This is not the solution. Skills such as logical thinking and structuring arguments can only be properly taught within an academic context. Subject teaching needs to develop these skills, and subject examinations need to assess them; they cannot be learned as an isolated "discipline".

The Diploma

The new Diploma is widely recognised to be the worst of all worlds. Sir Mike Tomlinson's report into 14-19 curriculum and qualifications correctly identified some of the main areas of the current system that need to be addressed:

> "We want scholarship in subjects to be given room to flourish and we want high quality vocational provision to be available from age 14. These are different, but both, in their own terms, are vital to the future wellbeing of young people and hence our country. We want to bring back a passion for learning, and enable all learners to achieve as highly as possible and for their achievements to be recognised. We must ensure rigour and that all young people are equipped with the knowledge, skills and attributes needed for HE, employment and adult life."[44]

But the Diploma – proposed by the report and now being introduced in a modified form – is the wrong solution, failing to address some areas of concern correctly and exacerbating the problems in others.

In conflating academic and vocational education the Diploma risks delivering neither effectively. The Education and Skills Committee report on the Diploma observed that "it has not always been clear to what extent the new programmes are intended to be vocational, or applied, or to serve a more general educational purpose".[45] The requirement that at least 50 per cent of all subject content must be "applied learning", taking place in a "work-related environment", undermines the rigorous, academic aspects of the curriculum; insisting on an academic slant and academic assessment for the vocational aspects risks jeopardising the effectiveness of that vocational training.[46]

The idea behind the Diploma is to create a behemoth that covers all careers options. The result is that it does not do any part well. It attempts to create the illusion of a comprehensive and rounded education – incorporating 10 days' work experience, for example – but much of this is ersatz.

As shown in Chapter 1, employers' main concern is that school-leavers have logical thinking and critical reasoning skills. They want rigorous academics, genuine work experience and vocational qualifications that are approved by vendors, employers and professional and trade bodies.

The Diploma attempts to compensate for the academic deficiencies of the current A-level structure by introducing specific units focusing on functional skills, thinking and synoptic assessment, and by requiring a new extended project.[47] But these reforms are the wrong way to introduce the necessary change. Instead of having separate assessment of these skills, they should be incorporated into the fundamental way all subject content and skills are taught and assessed.

43 OCR (2009), *AS/A-Level Critical Thinking Specification*.
44 Working Group on 14-19 Reform (2004), *14-19 Curriculum and Qualifications Reform: Final Report*.
45 House of Commons (2007), *14-19 Diplomas*, Education and Skills Committee.
46 Qualifications and Curriculum Authority (2009), www.qca.org.uk.
47 Ibid.

4
Utility, parity, equality

A-levels have changed because politicians and society have wanted them to. The hollowing of A-levels is directly linked to some of the most important trends in UK education – and politics – over the last 30 years.

Education as a means to an end

A defining theme of education policy over the period is the idea that a qualification is a means to a wider social end rather than an end in itself. Government has come to see qualifications as a means to achieve goals of social cohesion and economic growth, and a means to measure the quality of institutions. This utilitarian view is at odds with what should be the spirit of A-levels – the fostering of individual academic enquiry and independent thought as preparation for university.

The dogma of equivalence

An integral part of utilitarianism is the idea that education – for example, a particular A-level – delivers an outcome of fixed value which can be measured and equated to the outcomes of other A-levels and qualifications. Like people invited to sleep in the fabled Procrustean bed, subjects will be sliced and stretched to fit an arbitrary measure of value. This is epitomised by the UCAS points system for university entry and by school league tables, which rank all subjects equally.[48]

This delivers a world which makes sense to the bureaucratic mind but bears little relation to reality. Mathematics and Media Studies are completely different qualifications with differing "worth" depending on the objective of the person doing the qualification – yet there is a belief that they must be of the same "difficulty" and have the same "value". Subject interest groups and traditionalists suggest that "easy" subjects should be removed, or given lower value. In the UCAS system, for example, Further Mathematics A-level may be awarded more points than other subjects.[49] In reality students and institutions know very well which qualifications have greatest value in particular marketplaces.

The drive for equivalence is a pervasive and dangerous idea that is undermining the quality of particular A-levels. A-level Further Mathematics is now intentionally designed as "more" maths not "harder" maths, to keep it at the same difficulty level as the regular Mathematics A-level.[50]

The solution is not to adjust the qualifications framework in order to give greater value to certain qualifications than others. This does not address the problem. In fact the solution is to abandon the idea of equivalence and to allow students, universities and employers to judge the value of qualifications in practice.

The top universities find it hard to differentiate

Universities have already come under criticism for trying to distinguish between a growing number of candidates achieving similar grades. Several universities, including Oxford, Cambridge, UCL, Imperial, Bristol, Nottingham and Birmingham, have introduced their own entrance exams for a number of courses to try to assess particular academic skills that A-levels fail to test, such as critical thinking and problem solving.[51] The Chemistry department at Imperial College is now putting grade requirements on particular A-level modules.[52]

Acknowledging the need to distinguish between top-performing candidates, a new A* grade is being introduced at A-level. However, universities including Cambridge and Imperial College which have signalled an intention to adopt the new grade have been advised by bodies such as the National Council for Educational Excellence that they should not rush to include it in their admissions criteria.[53]

48 UCAS (2009), www.ucas.com.
49 Campaign for Science and Engineering (2008), *Higher UCAS Points for Science and Mathematics*.
50 Qualifications and Curriculum Authority (2009), *AS/A-level criteria in mathematics subjects: consultation*: "The content of AS level further mathematics should not be dependent on the content of AS level mathematics".
51 The BioMedical Admissions Test (BMAT) is a subject-specific admissions test taken by applicants to certain medicine and veterinary science courses at Cambridge, Oxford, Imperial, UCL and the Royal Veterinary College and was designed to assess academic skills and aptitude rather than knowledge. Cambridge produces Sixth Term Examination Papers (STEP), a mathematics admissions test to help pick out the most academically able students for oversubscribed courses, while Oxford uses the English Literature Admissions Test (ELAT) as the English equivalent and the History Aptitude Test (HAT) for testing the skills of History applicants. Thinking Skills Assessments are also used by Oxford, Cambridge and UCL to test critical thinking and problem solving skills for courses such as engineering, economics and philosophy. 11 British universities now use the two-hour National Admissions Test for Law to enable them to attain "a more rounded picture of their applicants' abilities" than shown by the A-level. See www.admissionstests.cambridgeassessment.org.uk; www.lnat.ac.uk; www.history.ox.ac.uk.
52 The standard offer for October 2009 entry was AAA in Chemistry, Mathematics and one other subject (not General Studies), and for the three individual module grades at A2-level to be AAA or AAB.
53 Sugden, J. (2009), "Cambridge bumps up entry criteria as three As no longer good enough", *The Times*, 16 March.

Widening participation has been a key policy aim

A central idea of education policy since the 1970s has been to widen participation. This is right if the academic rigour of qualifications is maintained. In that case, the outcome of widening participation is straightforward: a much better educated nation. However the idea has been to change post-16 education so that it is more accessible to people who were not attracted by the previous versions of A-levels. The drive to widen participation has also manifested itself, for example, in the re-designation of polytechnics as universities and the replacement of O-level by GCSE.

Hollow A-levels fail to challenge lower ability students

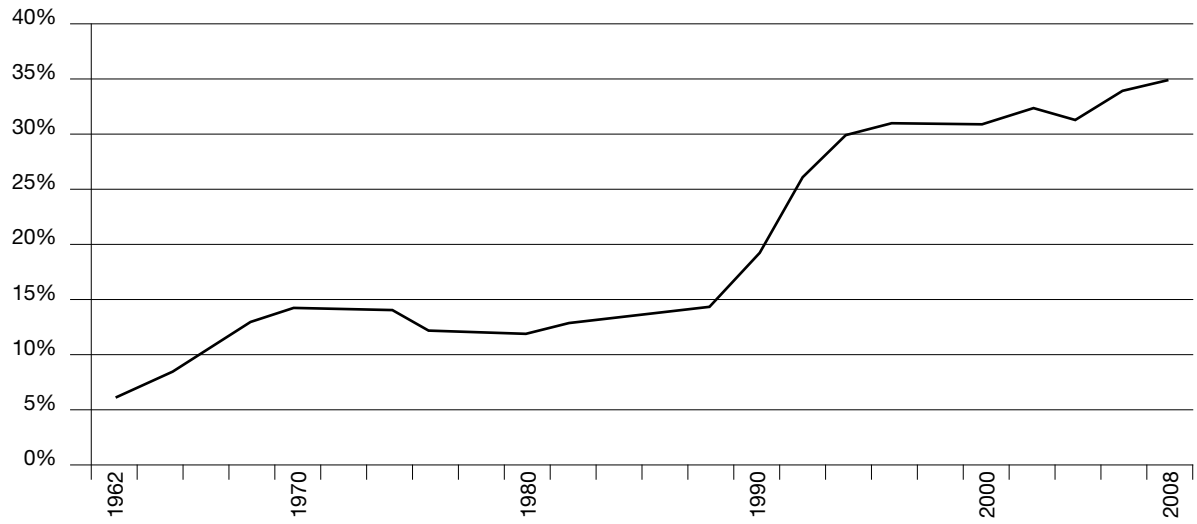
There is a widespread belief that a reduction in academic rigour was and is necessary to widen participation.[54] In interviews with *Reform*, leading universities have said that although the A-level is no longer academically challenging enough for their purposes, they think it is helpful for lower performers. In fact, students at the lower end of ability are capable of being stretched more. *Reform* interviewed admissions tutors at five of the lower-ranking new universities. There was a strong view that students at that level are capable of more in-depth thinking and insight. They reported that their applicants were also not being stretched at school to "think for themselves" and were being entered for less-challenging exams than they were capable of. The failure to have high expectations for these median students was also leading to a decline in academic and basic skills.

There was a consensus across subjects and ability ranges that students could achieve far more. Those who operate in the middle and lower tiers of UK education say that the problem is not students' potential capabilities. It is specifically the failure of proper teaching combined with a rigid examination system. Academically hollow A-levels are not serving the interests of the less-academically able.

Major change in A-levels has not achieved a great increase in participation

As shown below, the major increases in A-level participation took place from 1988 to 1993 whereas the greatest change in A-levels took place with the introduction of Curriculum 2000 in 2000.[55] This demonstrates that the myth that widening participation is responsible for changes in the A-level is false. The A-level was no doubt a minority qualification in the 1960s and 1970s but by the 1990s it was mainstream. There can be no excuse that the changes over the last decade have been driven by more people sitting the exam. The changes in A-levels have not been driven by – and have not driven – an increase in participation.

Figure 5: Under-21 year olds entering HE as a percentage of 18 year olds
Source: Dearing, R. (1997), *Report of The National Committee of Inquiry into Higher Education;* HMSO (2001-2007), *Participation Rates in Higher Education 1999-2006*[56]



54 McGaw, B. (2000), *Some research issues for the National College for School Leadership*.
55 Dearing, R. (1997), *Report of The National Committee of Inquiry into Higher Education*; HMSO (2001-2007), *Participation Rates in Higher Education 1999-2006*.
56 1998 estimate.

Universities have been replaced by bureaucracy

Reform has written previously about the greater role of central government and central agencies in education policy since around 1980.[57] A-levels have been subject to the same change. The additional finding for A-levels is that, over a much longer period, universities have steadily withdrawn from their involvement with A-levels, despite the fact that A-levels have remained the key access qualification.

Universities instituted A-levels

Historically universities have played a key role in upholding exam standards; in the first half of the 20th century they took a leading role in setting school examinations. The Oxford and Cambridge exam boards were founded in 1857 and 1858 respectively, and were later joined by other university-backed boards such as the Joint Matriculation Board and the University of London School Examinations Board.[58] Examinations were developed alongside preliminary examinations for undergraduates and were shaped by the requirements of university entry. Academics took principal responsibility for developing examinations.[59]

Universities also played a key role in regulating the examination system. The Secondary School Examinations Council (SSEC), established in 1917 to co-ordinate the standards of the various examining bodies, had representatives from universities, local education authorities and the teaching profession.[60]

This link has become weaker over time, with academics giving way to teachers and playing a progressively reduced role in the exam setting process. Responsibility for regulation was also taken away from universities. Upper-secondary education was reoriented away from university entrance by removing the university exam boards from the SSEC.[61]

Government took control

More recently the role of universities has been supplanted by government. Until 1964 the exam boards responsible for A-levels were overseen by the Secondary Schools Examination Council, which was then replaced by the Schools Council. However the Schools Council was soon criticised for allowing academic standards to decline and was replaced by the Secondary Examinations Council in 1982 and then by the government-led Schools Examination and Assessment Agency in 1988.[62] The organisation has been rebadged several times since then, but remained a government agency.

Universities have steadily withdrawn from involvement in school curricula and examinations due to changing priorities and a shifting of academics' financial incentives, primarily to research. Kathleen Tattersall, Chair of Ofqual, has observed that:

> "The Universities' own agendas and priorities changed, leading to their gradual withdrawal from direct involvement in the examination system. [Their involvement was replaced by new bodies] which, according to the fashion of the time, combined curriculum and assessment, or qualifications across the academic/vocational spectrum."[63]

Currently A-levels are set through a three-stage process. The QCA develops initial criteria for each subject. Then the exam boards produce their specifications: syllabuses and sample papers and mark schemes. Ofqual then approves the specification, regulating to maintain consistency of quality and standards over time.

Regulation without representation

The new Office of the Qualifications and Examinations Regulator (Ofqual) has been entrusted with regulating the quality and standards of qualifications and assessment.[64] But this body is dominated by bureaucrats and professional regulators with little (in some cases no) experience of education. Ofqual's management group and supervisory committee consists largely of civil servants, exam board members and quangocrats. There are no current academics on the management group or the committee; only one member of the management group has worked in higher education.[65]

57 Haldenby, A. et al. (2008), *The mobile economy*, *Reform*.
58 Tattersall, K. (2008), "The Relationship of Examination Boards with Schools and Colleges: a historical perspective", speech given to Cambridge Assessment, June.
59 Petch, J. (1953), *Fifty Years of Examining*.
60 Oxford University Archives (1999), *Delegacy of Local Examinations*.
61 Wolf, A. (2003), "Sixth-form and undergraduate studies have always been symbiotic, so why are they not more integrated?", *Times Higher Education*, 10 January.
62 Kingdon, M. (1991) *The Reform of Advanced Level*.
63 Tattersall, K. (2008), "The Relationship of Examination Boards with Schools and Colleges: a historical perspective", speech given to Cambridge Assessment, June.
64 Ofqual (2009), www.ofqual.gov.uk.
65 Ibid.

Ken Boston, the former Chief Executive of the QCA, has criticised the Government for interfering in the regulation of exams. Ofqual, the new regulator, is intended to be fully independent from government. Although it will report to Parliament rather than Ministers, and its senior management are not Ministerial appointments, the DCSF has placed "observers" on the interim Ofqual board and its committees, potentially inhibiting free discussion and criticism of government policy.[66]

The result is that academics now have very little involvement at any stage: in determining curricula, in developing exams or in regulating them. Ofqual's Director of Regulation, whose responsibilities include regulatory policy and the Qualifications and Credit Framework – the *raison d'être* of Ofqual – has had a career in regulation with no education experience whatsoever, having spent 19 years at Ofwat, the water regulator.[67]

Academic exclusion

Equally the Qualifications and Curriculum Authority (QCA) reflects the wishes of government rather than academia. Of the 13 members of the board of the QCA – the body responsible for developing curricula – only two work in higher education, and neither are practising subject specialists. Many have backgrounds in the Civil Service, business, children's services, charities or quangos. There are no academics on the QCA executive.[68]

There is an active bias against academic expertise in curriculum development. The QCA recruits "associate consultants" to help with this process. These are hired according to eight experience criteria, including "developing and supporting diversity and inclusion policies" and "promoting and developing future curriculum thinking and practices to better meet the needs of the learner". Only one of the eight criteria refers to subject knowledge at all. But even this requirement – for "specific subject expertise across the national curriculum and national qualifications framework" – precludes academics with an advanced subject specialism.[69]

Other countries place a high value on academic input

Leading international performers consult academics extensively. In the Netherlands, the Ministry of Education is required to consult a board representing universities when drawing up the National Curriculum.[70] In France the National Curriculum Agency, which writes the curriculum, comprises 22 educators including 11 university lecturers.[71] In South Korea school leaving exams are developed by teachers and academics.[72] The Finnish matriculation exam is set by a board nominated by the Ministry of Education on the recommendation of universities.[73]

Weighing the pig – a rules-obsessed, target-centric culture

Education has responded to many of the culture changes in wider society. As society has become more litigious, every element of life has become more focused on targets and rules, encouraged by those who do not like random variables entering the equation. This has resulted in the removal of discretion and expertise from teaching and marking. There is a pervasive desire for everything to be measured, quantified and compared. The target-obsessed culture is not the preserve of government; businesses have introduced it to monitor the performance of their executives.[74] As well as contributing towards the need for equivalence, this culture has created pressure for every element of learning to be examined. Students can no longer learn just for the sake of it.

66 Boston, K. (2009), "Independent regulator? The signs are not good", *The Independent*, 30 April.
67 Ofqual (2009), www.ofqual.gov.uk.
68 Qualifications and Curriculum Authority (2009), www.qca.org.uk.
69 Ibid.
70 Qualifications and Curriculum Authority (2008), International Review of Curriculum and Assessment Frameworks Internet Archive.
71 Ibid.
72 Park, S. (2008), "On College-Entrance Exam Day, All of South Korea Is Put to the Test", *The Wall Street Journal*, 12 November.
73 Ylioppilastutkintolautakunta (2009), www.ylioppilastutkinto.fi/en
74 *Management Today* (2009), "Why excessive goal-setting is bad for business", 1 June: "Setting targets is so tightly woven into the way we do business that it's difficult to conceive of a world without performance measures or departmental goals".

A test of institutional as well as individual performance

Historically examinations were used to assess individual students. Since 1992 they have been used in league tables and by the Government to assess the performance of schools. This has been exacerbated by the Government producing specific targets to be achieved by "good schools". The Government has targets for all levels of education from early years to post-18.[75]

Targets narrow the focus of schools to specific subjects and results, and lead to a proliferation of "teaching to the test".[76] In order to reach targets institutions focus on getting the results at any cost rather than widening students' understanding of a particular subject. Learning becomes focused on key facts and figures that will ensure that students reach the required grade. Individuals become reduced to their grade potential with evidence of extra classes for those that are on the borderline between what is classed as a good or bad result.[77]

Institutions desiring to achieve highly in the league tables have an incentive to choose the easier option.[78] This creates pressure on exam boards to dumb down to attract more business from schools and consequently there is a conflict of interest within the bodies that are meant to be the guardians of standards.[79] This all leads to the marginalisation of what are seen as difficult subjects. The decline in the teaching of languages in schools is evidence of this.[80]

It's all within the rules

Many of the developments in education and marking have been a result of the battle between reliability – ensuring consistency of and comparison between results – and validity – ensuring that results reflect students' abilities and knowledge. The desire for reliability and being able to demonstrate that rules and structures have been followed has diminished qualitative assessment. As shown in Chapter 2, A-levels have slowly become focused around step-by-step short answer questions (in the sciences) and rules-based marking (in the arts) which prevent markers from exercising discretion about the quality of an answer. In its most extreme form, multiple choice offers a completely reliable method of assessment, whilst removing any potential for originality, creativity or argument.[81]

The wrong debate about participation and elitism

All of these policy changes have taken place with a strong undercurrent of anti-elitism. This is entirely artificial as Britain's elite educational institutions continue to exist and thrive. However there is superficial disapproval of top institutions; the educational establishment does not want to be seen to be relying on academic leaders. The top universities themselves are reluctant to speak out for fear of reinforcing perceptions of elitism.

Equally, traditionalists need to move on from a hackneyed debate about whether the number of university places needs to be reduced. All the evidence suggests that we need more academically qualified students, not fewer.[82] As shown in Chapter 1 the largest block of students at 18 are already those going on to higher education.[83]

75 Examples include increasing the proportion achieving 5 A*-C GCSEs (and equivalent), including GCSEs in both English and Mathematics, to 53 per cent by 2011 from 46.3 per cent in 2008. Another target is to increase the number of 19 year olds with a Level 3 qualification, from 49.8 per cent now to 54 per cent by 2011.
76 *The Daily Telegraph* (2008), "Ofsted: Schools 'teaching to the test'", 21 July.
77 Smith, D. (2007), *Boost your borderline students.*
78 *The Daily Telegraph* (2009), "Schools accused of promoting 'easy' computing qualifications", 28 March.
79 *The Daily Telegraph* (2006), "Independents rescue falling exam standards", 2 September. "Martin Stephen, the high master of the school (St Pauls) , said 'commercial pressures' were encouraging exam boards to make their standard tests easier."
80 Evans, E. et al. (2008) *Language learning at key stage 3: The impact of the key stage 3 modern foreign languages framework and changes to the curriculum on provision and practice*. "Two thirds of schools surveyed do not require all pupils to study a language beyond KS3. Only 16 per cent require all pupils to learn a language in KS4. Most other schools operate a selective policy for compulsory language learning, applying it exclusively to pupils in top sets."
81 *The Guardian* (2008), "Expert calls for multiple choice tests at A-level", 20 April.
82 Haldenby, A. et al. (2008), *The mobile economy*, *Reform*.
83 Department for Children, Schools and Families (2009), *Youth Cohort Survey*.

5
A new level: renewing the A-level

Ersatz education will only be challenged by much greater openness, transparency and honesty in the system and by the academic world reclaiming its role. Universities should be responsible for ensuring that the A-level delivers the academic foundations that they need.

Universities should approve A-levels

Universities should "quality assure" individual subject A-levels, cooperating with examination boards to develop them. Universities should be able to veto exam boards' specifications if they are not sufficiently rigorous or do not require the right content or the development of the correct skills.

Heads of Departments are best suited to the role

In considering where responsibility should lie in universities, the most appropriate level appears to be Heads of Departments, who have a good overview of their subject and are not running entire universities as are Vice Chancellors. Most subjects have groupings of leading academics. For example, if this was applied to the four subjects that *Reform* has considered specifically, the groups would be as follows:

- Heads of Departments of Mathematical Sciences[84]
- Council for College and University English[85]
- Heads of Chemistry UK[86]
- History has a few groupings such as History UK[87] – however no formal grouping of Heads of Department exists. History academics have indicated to *Reform* that the establishment of such a group would be desirable.

Reform has investigated a number of other mechanisms including giving the power to specific universities, groups of universities or institutions such as the Royal Society and British Academy. The sense was that the Heads of Department groups present the broadest base for qualifications to be effectively monitored whilst preserving the academic subject-based integrity of the A-level. It also avoids the need for the establishment of yet another quango.

These academic groups would be expected to make their own arrangements to work with the exam boards. They would naturally consult schools and headteachers; many academics are already in touch with sixth forms in their local area. Academics already work with Cambridge Assessment on the Pre-U. The change would restore the link between universities and their entrance exam. *Reform*'s discussions with universities suggest that they would take pride in having this responsibility and wear it as a badge of honour.

Transfer funding from Ofqual and the QCA to universities to carry this out

It is important that universities have the financial support to carry out this role properly. The funding that is currently supplied to the QCA and Ofqual to carry out its functions with respect to A-levels should be redistributed to schools. Schools would pay exam boards, as at present, for the examinations that their students sit. The exam boards would then pay a levy to the academic group for each subject.

This would be similar to the successful regulatory structures in the water and communications industries. For example Ofwat, the water regulator, is funded through a levy imposed on utilities. This allows the funding, and therefore the regulation, to be entirely independent of government and other interested parties.

Some of the initial steps universities should consider taking:

Re-establish linear A-levels: The current proposal for four modules is not enough, particularly as it is not being implemented in some science and maths A-levels which have arguably suffered most from modularisation.

Allow new entrants into the exam market: Any exam board should be allowed to be set up as long as their syllabuses and exams are approved by the new academic panels. They would not have to offer all subjects.

84 http://www.coventry.ac.uk/ec/HODOMS/
85 http://www.ccue.ac.uk/
86 http://www.rsc.org/Education/HCUK/
87 http://www.history-uk.ac.uk/

From rules to judgement

Improvements in technology reduce the cost of transparency and can therefore increase the ability for judgement to be exercised by examiners, universities and students. These can replace the need for a cumbersome rules-based bureaucracy, reduce the gaming that is currently much in evidence and encourage elegance and originality.

Greater judgement using virtual marking

Examiners should be able to use their professional judgement to assess candidates without unnecessary rigid marking schemes and rules. In some subjects like Mathematics this will mean more open-ended questions. In English it will mean more scope for examiners to judge the overall quality of answers. Virtual working can be very effective in this activity. Exam boards are already dividing up A-level responses so that subject experts can mark answers in their fields. It makes sense for these people to use their subject knowledge to greater effect.

Allow greater transparency of marked papers

This process will be kept "honest" by allowing teachers access to monitor online marked papers. There may be a trade off in increased appeals but this should be considered a price worth paying for greater intellectual integrity.

Increase granularity of school results

There will always be a desire to compare and contrast schools but the basis on which it is done should be more granular and transparent. Rather than league tables based on a single points score, schools should publish subject results and student destinations. Sampling can also provide a more sophisticated measure. Leading international systems place greater emphasis on school inspections and the complete results from sample tests to inform the direction of education policy.

Broaden criteria for university entry

University admissions should be based on grades, not a total points score. Universities should take advantage of technology to take more detailed, granular information about students into account when processing applications. The higher-ranked universities generally already offer individual students graded offers in the subjects they are studying, and universities frequently have to do this when considering mature students – whom we noted earlier are generally better prepared.

Abolish the National Qualifications Framework

The National Qualifications Framework should be abolished. The demands of different qualifications are so diverse that the comparisons it presents are largely meaningless. It is misleading to employers, educators and learners and no substitute for granular information on the quality and rigour of a qualification.

Immediate steps

The Government should have a duty towards ensuring that rigorous examinations are available to all school children. There are a number of plans in the pipeline that threaten the intellectual coherence of the A-level that will need to be dealt with in advance of regulatory reform.

Abandon the Use of Maths A-level

The QCA is currently consulting on the new A-level Mathematics curricula including criteria for the new Use of Maths A-level. This project should be abandoned. These changes will lead to a further hollowing out of the subject and will not achieve the stated aim of increasing participation in Mathematics at A-level.

The Diploma should be abolished

All Diplomas yet to come into service should be abandoned. Teamwork, self-management, critical thinking and "functional skills" should be taught in the context of academic subjects. *Reform* has previously proposed that employers should lead vocational education rather than government.[88]

The A-level should continue to be available in all schools

A rigorous A-level available in all schools is a vital tool of social mobility. An examination that can recognise brilliance and give all students the best preparation for their careers and further study is a foundation for genuine meritocracy. Freeing up the market in qualifications before dealing with the major issues in schools will result in fewer poor-performing schools offering well-regarded academic qualifications. This would only serve to reinforce the developing education apartheid.

88 Haldenby, A. et al. (2008), *The mobile economy, Reform*.

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Appendix

Public Examination Questions 1951, 1970, 1990, 2000, 2008 GCE Advanced Level

University of Cambridge Local Examination Syndicate/OCR

For each subject a set of sample questions on a related topic is provided for comparison. From 1998 OCR replaced University of Cambridge Local Examinations Syndicate.

Section 1: Chemistry

For each year a sample question relating to calculating parameters – such as molar mass, temperature and pressure – is provided for comparison.

July 1951
Paper 2

Question

1. a) Explain why the dissociation of a gas changes its apparent density.

   b) Calculate the increase of pressure produced in a container of volume 250 ml. at 50°C by completely vaporising it in 0.100 gm. of a volatile liquid whose molecular weight is 92.

   c) If the substance dissociates into two separate parts to the extent of 40.0%, what will be the total increase of pressure?

   .....

   [Assume that the density of hydrogen is 0.09gm. per litre at N.T.P., or that the G.M.V. = 22.4 litres at normal temperature and pressure.]

Answer

1. a) Gas dissociation is a process in which ionic compounds (complexes, molecules, or salts) separate or split into smaller molecules, ions, or radicals, usually in a reversible manner.

   Consider the following dissociation:

   $N_2O_4 \rightarrow 2NO_2$
   1 mole $\rightarrow$ 2 moles

   One mole of a gas at standard temperature and pressure occupies 22.4 L mol^{-1}. Two moles will occupy twice this, e.g. 44.8 L mol^{-1}. The molecular mass of the two compounds are not the same. The density is the ratio of the mass to the volume:

   $d = \frac{m}{v}$

   $N_2O_4 = \frac{92\ g\ mol^{-1}}{22.4\ L\ mol^{-1}}$

   $NO_2 = \frac{46\ g\ mol^{-1}}{44.8\ L\ mol^{-1}}$

   b) pV = nRT where p = pressure, V = volume, n = number of moles, R = Rydberg constant and T = temperature.

   $\Delta pV = \Delta nRT$

   $\Delta p = \frac{\Delta nRT}{V} = \frac{\left(\frac{0.100g}{92g\ mol^{-1}}\right)\ x8.3143\ mol^{-1}K^{-1}\ x\ 323.15K}{250\ x\ 10^{-6}m^3} = 11681.6\ Pa$

   A change of Δp of 11681.6 Pa ≈ 87.6 Torr

   Number of moles = $\frac{mass}{M_r} = \frac{mass}{molecular\ mass}$

   c) Vaporised n = $\frac{0.100\ g}{92\ g\ mol^{-1}}$ = 1.087 X 10^{-3} mol – 40% of these dissociate

   40% of 1.087 X 10^{-3} mol = 4.3478 X 10^{4} mol

   Remaining 60% = 6.5217 X 10^{-4} mol

   New Δn = [2 (4.3478) + 6.5217] X 10^{-4} mol = 1.5217 X 10^{-3} mol

   Leading to Δp = 16354.2 Pa ≈123 Torr

June 1970
Paper 1

Question

3. a) Distinguish between the *vapour density* and the *density* of a gas. [3]

b) Calculate:
i) the vapour density, ...
ii) the density, of a sample of dry air at 96°C and 779 mmHg, the volume composition of which is nitrogen 78%, oxygen 21%, argon 1%.

..... [8]

c) State *Le Chatelier's Principle*.

..... [1]

d) Write both the equations shown below and draw an arrow to show how, if at all, the composition of each equilibrium mixture will change when the pressure is increased. State also what effect this increase in pressure will have upon the vapour density. [5]

i) $N_2O_4 \rightleftharpoons 2NO_2$ .....

ii) $2HI \rightleftharpoons H_2 + I_2$ .....

e) A saturated solution of slaked lime contains a higher concentration of calcium hydroxide at 10°C than at 20°C. How does this help to decide whether the dissolution of slaked lime in water is endothermic or exothermic?

..... [3]

[N = 14.0; O = 16.0; Ar = 40.0; the gram-molecular volume of a gas is 22.4 litres at s.t.p.]

Answer

3. a) Density of gas is the mass of the gas divided by the volume it occupies.

Density = $\frac{mass}{volume}$

The vapour density is the relative density of a vapour with respect to that of a reference gas (usually H_2.)

Vapour density = $\frac{density\ of\ vapour}{density\ of\ H_2} = \frac{m_{vapour}/v}{m_H/v}$

Therefore $\frac{M_{R\ vapour}}{M_{r\ H}} = \frac{M_{R\ vapour}}{2}$

b) $pV = nRT \quad T = 369.15K$

$pV = \frac{m}{M_R}(RT)$ $p = 779$ mm Hg $= 103858$ Pa

$\frac{m}{v} = \frac{pM_R}{RT}$ $M_{r\,(air)} = (0.78 \times 28[M_r \text{ of nitrogen}]) + (0.21 \times 32[M_r \text{ of oxygen}]) + (0.01 \times 40[M_r \text{ of argon}]) = 28.96$ g mol^{-1}

$\text{Density}_{(air)} = \frac{103858 \text{ Pa} \times 28.96 \times 10^{-3} \text{ kg mol}^{-1}}{83143 \text{ J K}^{-1} \text{ mol}^{-1} \times 369.15K} = 0.980$ kg m^{-3}

Vapour density: = 14.48 dimensionless

c) *Le Chatelier's Principle:* If a chemical system is at equilibrium and is perturbed by a change in concentration, temperature, volume or pressure the equilibrium will shift to counteract such change.

d) i) $N_2O_4 \rightleftharpoons 2NO_2$
1 mole 2 moles

The equilibrium moves to increase the proportion of N_2O_4 and decrease the proportion of NO_2 as N_2O_4 has a higher M_r than NO_2. Then as the vapour density is proportional to the average M_r of the gas mixture, the vapour density is increased.

$N_2O_4 \leftarrow 2NO_2$

The reason for this is because an increase in pressure causes a decrease in volume.

ii) $2HI \rightleftharpoons H_2I_2$
2 moles 2 moles

As the equilibrium remains unchanged, there is no accompanying change in vapour density.

e) $Ca(OH)_2 \rightleftharpoons$ slake lime
$Ca(OH)_2 \rightleftharpoons H_2O + CaO$
$\rightarrow$ Endothermic

As temperature is raised more $Ca(OH)_2$ are converted. Equilibrium shifts towards products.

June 1990
Paper 1

Question

7. In a pathology laboratory, a sample of urine containing 0.120g of urea, NH_2CONH_2, (M_r - 60) was treated with an excess of nitrous acid. The urea reacted according to the following equation:

   $NH_2CONH_2 + 2HNO_2 \rightarrow CO_2 + 2N_2 + 3H_2O$

   The gas produced was passed through aqueous sodium hydroxide and the final volume measured.
   What was this volume at room temperature and pressure?
   [Molar volume of a gas at r.t.p. is 24 000 cm^{-3} mol^{1}.]

   A 9.6 cm^{-3}

   B 14.4 cm^{-3}

   C 48.0 cm^{-3}

   D 96.0 cm^{-3}

   E 144.0 cm^{-3}

Answer

7. ANSWER D.

June 2000
Paper 1

Question

8. The limescale that collects in kettles in hard water areas is mostly carbon carbonate. It can be removed fairly harmlessly by a warm solution of vinegar, which contains ethanoic acid. The limescale dissolves with fizzing and a solution of calcium ethanoate remains.

a) Write a balanced equation for the reaction between ethanoic acid and calcium carbonate.

..... [1]

When the solution produced in (a) is evaporated, and the resulting solid calcium ethanoate heated strongly in a test-tube, an organic compound G is formed which condenses to a colourless liquid. The residue in the tube consists of calcium carbonate.

b) When 0.10 g of G was injected into a gas syringe at a temperature of 383K and a pressure of 1.0 X 10^5 Pa (1 atm), 55 cm^3 of vapour were produced.

Calculate the relative molecular mass of G. ..... [2]

c) Compound G is neutral and water-soluble. G does not react with sodium metal nor with Fehling's solution but it does react with alkaline aqueous iodine. Suggest a structural formula for G. Justify your answer by reference to these properties of G.

..... [5]

d) Construct a balanced equation for the formation of G by the action of heat on calcium ethanoate.

..... [1]

e) Suggest a simple one-step test you could carry out to confirm the identity of the functional group present in G. You should give the reagent and the observation you would make.

..... [2]

f) Suggest the structural formula of the organic product you might expect when calcium propanoate, $(CH_3CH_2CO_2)_2Ca$, is heated strongly.

..... [1]

Answer and marking guidance

8. a) $2CH_3CO_2H + CaCO_3 \rightarrow Ca(CH_3CO_2)_2 + CO_2 + H_2O$ [2]

[salvages: allow [1] for $CaCO_3 \rightarrow CO_2$. allow [1] for equation with H_2CO_3 instead of $CO_2 + H_2O$]

[ignore Ca-O bonds in the product]

b) moles = pV/RT = (1 X 10^5 X 55 X 10^{-6})/(8.31 X 383)
= 1.728 X 10^{-3} moles [1]

M_r = 0.1/(1.728 X 10^{-3}) = 58 (57.8,57.9) [1]

Answer and marking guidance continued

8. c) NB:
- Context is important – if conclusions are not related to the texts, deduct max [1] for whole of part (c).
- Candidates may identify G first, and then justify their answer (as the question asks them to do!), so may not state explicitly the conclusions to the tests. e.g. "G is propanone, because it is neutral, does not react with Na,..etc". In this case, deduct max [1] also.

G is polar or hydrogen-bonded (water solubility) [1]

G is not RCO_2H/carboxylic acid (neutral) [1]

G is not an aldehyde (Fehling's test) [1]

G is not an alcohol/acid/phenol/ or does not contain –OH group (Na metal) [1]

G must contain the /CH_3CO/$CH_3CH(OH)$/ group or is a methyl ketone etc (OH^-/I_2) [1]

Gives a /yellow/cream/ ppt./solid/ or / iodoform/CHI_3/ [1]

G is CH_3COCH_3 [must be the formula – NOT name] [1]

d) $Ca(CH_3CO_2)_2 \rightarrow CH_3COCH_3$ (or C_3H_6O) + $CaCO_3$ [1]

e) Add (2,4-)DNP(H) (dinitrophenylhydrazine) (Brady's reagent) (*allow c.e.*) [1]

G will give a yellow/orange/red ppt. (*allow c.e.*) [1]

f) $CH_3CH_2COCH_2CH_3$ or Et_2CO [1]

June 2008
Trends and Patterns

Question

2. This question is about molybdenum and iron.

Molybdenum steel is extremely hard.

Molybdenum is made by heating molybdenum(VI) oxide, MoO_3, with aluminium powder.

a) Construct an equation to show the reduction of molybdenum(VI) oxide to molybdenum metal by aluminium.

..... [1]

b) Molybdenum has the electronic configuration $[Kr]4d^5 5s^1$ where [Kr] represents the electronic configuration for krypton.

Complete the electronic configuration for Mo^{3+} and use it to explain why molybdenum is a transition element.

[Kr] .....

Explanation ..... [1]

c) Molydenum(IV) oxide, MoO_2, can be oxidised by dichromate(VI) ions, $Cr_2O_7^{2-}$, under acidic conditions.

The relevant half-equations are as follows,

$MoO_2(s) + 2H_2O(l) \rightarrow MoO_4^{2-}(aq) + 4H^+(aq) + 2e^-$

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$

Construct the equation for the oxidation of MoO_2 by $Cr_2O_7^{2-}$ ions under acidic conditions.

..... [2]

d) Iron can form the ferrate(VI) ion, FeO_4^{2-}.

i) What is the formula for potassium ferrate(VI)?

..... [2]

ii) Aqueous ferrate(VI) ions can be made by the oxidation of iron(III) oxide by chlorine in alkaline conditions.

$Fe_2O_3 + 3Cl_2 + 10OH^- \rightarrow 2FeO_4^{2-} + 6Cl^- + 5H_2O$

A 1.00g sample of Fe_2O_3 is added to $10.0cm^3$ of 4.00 mol dm^{-3} KOH.

Which reagent, Fe_2O_3 or KOH, is in excess? Explain your answer.

..... [3]

Answer and marking guidance

2. a) $MoO_3 + 2Al \rightarrow Al_2O_3 + Mo$ (1)

b) [Kr] $4d^3$ and (Mo^{3+}) has an incomplete filled d-subshell (1)

c) Correct molar ratio of Mo and Cr species

$3MoO_2 + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 3MoO_4^{2-}$ (1);

But:

$3MoO_2 + Cr_2O_7^{2-} + 2H^+ \rightarrow 2Cr^{3+} + H_2O + 3MoO_4^{2-}$

d) i) K_2FeO_4 (1)

ii) Moles of $Fe_2O_3 = 0.00627$ (1)

Moles of $OH^- = 0.0400$ (1)

Fe_2O_3 in excess since there needs to be 0.0627 moles of OH^- / evidence of working out the reagent in excess (1)

Section 2: English

A sample question on Shakespeare is provided for comparison. For 2000 and 2008 this is taken from English Literature papers (following the division of English into separate Language and Literature qualifications). The 2008 question is taken from an AS-level paper as Shakespeare was covered in the first year of A-level study.

June 1951
Paper 2

Question

As You Like It

7. "The complete anatomy of love; a handbook of all its conventions." Consider As You Like It from this point of view.

Marking guidance

No formal guidance was provided. Examiners relied on experience and comparator scripts that benchmarked performance at different grades to assess responses.

June 1970
Paper 2

Question

Hamlet

3. b) 'There's a divinity that shapes our ends Rough-hew them how we will.'

Does Hamlet's experience prove the truth of his assertion?

Marking guidance

Marking schemes were provided. These were basic and allowed considerable freedom to reward original and innovate responses. Comparator essays and the examiner's team leader were the main point of reference.

June 1990
Paper 1

Question

Macbeth

3. b) Consider the dramatic presentation and significance of apparitions and the supernatural in Macbeth. [30]

Marking guidance

Markers were instructed to assess candidates on their ability to demonstrate:

1. Knowledge – of the content of the books and where appropriate of the personal and historical circumstances in which they were written.
2. Understanding – extending from simple factual comprehension to a broader conception of the nature and significance of literary texts.
3. Analysis – the ability to recognise and describe literary effects and to comment precisely on the use of language.
4. Judgment – the capacity to make judgements of value based on close reading.
5. Sense of the past and tradition – the ability to see a literary work in its historical context as well as that of the present day.
6. Expression – the ability to write organised and cogent essays on literary.

Additional guidance was provided on what a candidate might cover in his or her responses.

June 2000
Paper 1

Question

Othello

2. a) How important are honour and reputation to the characterisation and concerns of the play?

Marking guidance

Markers were advised that responses may include discussion of:
- The soldiers' code
- Expected behaviour for women
- Concern with others' opinion
- Selfhood, male values

Markers were instructed to assess candidates on their ability to demonstrate:
1. An ability to respond with understanding to texts of different types and periods.
2. An understanding of the ways in which writers' choices of form, structure and language shape meanings.
3. Knowledge of the context in which literary works are written and understood.
4. An ability to discuss their own and other reader's interpretations of texts.
5. An ability to produce informed, independent opinions and judgements.
6. An ability to communicate clearly the knowledge, understanding and insight appropriate to literary study.

Examiners were required to allocate marks (to a maximum of 25) as follows:

22, 23, 24, 25
Very good work, coherent, relevant, freshly personal and discriminating in response to the text and to the question; grasping the text as a while and, perhaps, in its time; evident ability to handle complex concepts in an appropriate style and to develop ideas by detailed reference to the text; the writing is likely to be very lively and sometimes highly individual, handling critical terms with ease and blending appropriate textual reference into the flow of the argument, which is firmly structured: fine sensitivity to nuance and tone. Passage: unusually sharp focus and relevance; close critical analysis of a higher order showing insight and perception; skilful use of text in argument, including range into the wider text when required.

18, 19, 20, 21
Good work, argued with insight into the significance and effect of the text studied; the candidate may be articulate and able to offer a well-organised argument that is consistently relevant and well focused; the ability to support by detailed reference to the text the views put forward in the essay and to use critical terms aptly; some individuality of approach may be becoming apparent: other answers may be very thorough. Essays will be well organised and well directed. Passage: critical analysis shows some insight and uses the text for detailed support, including range into the wider text when required by the question.

14, 15, 16, 17
Essays will display competence in framing an argument in response to a question and in showing appreciation of form, theme and character as appropriate to the question asked. Sensible discussion in a generally sound style; there may be occasional moments of personal insight or perceptive comment; analysis may not be full nor fully incorporated; textual details will be observed but not developed. Passage: relevant, with sensible choice of mostly apt material from the passage and from wider text, but where there is analysis it will not be in depth.

10, 11, 12, 13
Pedestrian work, working doggedly through text and question, failing to perceive some of the implications of both but making obvious points; nevertheless there will be occasions when ideas or personal response seem to be developing. Perhaps flawed by weaknesses of structure or lack of purposeful selectivity. Often characterised by disconnected assertion with limited textual reference and analysis; intermittent relevance and focus. Passage: generalised and undeveloped; knowledge presented, but lacking in textual reference either to the passage or to the wider text.

6, 7, 8, 9
Basically passable work, showing the beginnings of an analytical response to the text and some attempt to deal with meaning, but partial or simplistic; a basic knowledge of theme and character. Paraphrase and narrative may be used with some direction to the question. Powers of expression may be limited and critical terms used in a general way. Passage: basic identification of obvious qualities of the passage and task.

2, 3, 4, 5
Often literal minded, candidates at this level may struggle to frame statements and to put an answer together in response to the question, of which only part may have been grasped. Reference may not be accurate and misinterpretation may be evident; some attempt to hold to text and question may be apparent, often through uncritical narrative, summary or paraphrase. Limited powers of expression, usually with errors of syntax and spelling

0, 1
Inadequate by reason of lack of substance and inability to give expression to relevant ideas or responses. Accounts of text and question are likely to be inaccurate/unclear. Reserved for candidates who barely begin to make relevant observations.

May 2008
Drama: Shakespeare

Question

The Tempest

8. a) How far do you agree that Caliban is the character for whom the audience feels most sympathy? [30]

In the course of your answer:
- explain clearly how the play presents Caliban;
- comment on what the play suggests about the effects of ill treatment.

Marking guidance

Examiners were advised that responses should:

Deal with the three main aspects of the question: the possibly sympathetic view of Caliban in the play; the presentation of the character; and the effects on him of the ill treatment he receives (but not necessarily at equal length or in this order). Good responses may comment on Caliban as exploited underdog; the dramatic effects of his treatment by Prospero and others; and his surprising use of poetic language.

Examiners were instructed to assess candidates on their ability to demonstrate:
AO1: Communicate clearly the knowledge, understanding and insight appropriate to literary study, using appropriate terminology and accurate and coherent written expression.
AO4: Articulate independent opinions and judgments, informed by different interpretations of literary texts by other readers.
AO5i: Show understanding of the context in which literary texts are written and understood.

Markers were required to allocate marks (to a maximum of 30) as follows:

30, 29, 28, 27, 26, 25, 24
AO1: Consistently good command of written English in an appropriate register, blending reference to the text neatly into the argument; technical terminology tellingly deployed; cogently structured arguments closely related to the question under discussion.
AO4: Mature opinions and responses, formed and articulated as a consequence of intelligent thought directed at the text and the question, and informed as appropriate by different interpretations of the text under discussion.
AO5i: Good understanding, built into and informing the answer, of the place of the issues raised, in the context of the whole play.

23,22,21
AO1: Good command of written English in an appropriate register, blending reference to the text fully into the argument; technical terminology appropriately deployed; clearly structured.
AO4: Appropriate opinions and judgements formed as a consequence of intelligent thought directed at the text and the question, and informed by different interpretations of the texts under discussion.
AO5i: Clear understanding, built into and informing the answer, of the place of the issues raised, in the context of the whole play.

20, 19, 18
AO1: Controlled use of written English in an appropriate register, usually blending reference to the text successfully into the argument; technical terminology sometimes deployed to good effect; straightforward arguments properly related to the question under discussion.
AO4: Opinions and judgements competently formed and articulated as a consequence of sound thought directed at the text and the question; some awareness of possible different interpretations.
AO5i: Competent understanding, usually informing the answer appropriately, of the place of the issues raised, in the context of the whole play.

17, 16, 15
AO1: Usually controlled use of written English in an appropriate register, sometimes blending reference to the text successfully into the argument; some appropriate use of technical terminology; straightforward arguments broadly or doggedly pursuing the task set.
AO4: opinions and judgements expressed as a consequence of basically sound thought directed at the text and the question; limited awareness of possible different interpretations or alternative perspectives.
AO5i: broad understanding, sometimes informing the answer appropriately, of the place of the issues raised in the context of the play.

Marking guidance continued

14,13, 12

AO1: Some lapses in effective written English, while making an effort to blend reference to the text into the argument; possible use of some technical terminology; limited response to texts and tasks.

AO4: Some opinions and judgements outlined or asserted as a broad response to the text and the question; very limited awareness of possible different interpretations.

AO5i: Very basic ability to make straightforward links between the relevant issues and their place in the play.

11, 10, 9

AO1: Some lapses in effective written English, and making insufficient effort to blend reference to the text into the argument; occasional use of technical terminology; limited response to texts and tasks.

AO4: A few opinions outlined or asserted as a very limited response to the text and the question; occasional awareness of possible different interpretations.

AO5i: Very restricted ability to make straightforward links between the issues and their context in the play.

8, 7, 6, 5, 4, 3, 2, 1

- Not offering an adequate attempt to answer the question or complete the task (consequently, not sufficiently addressing the Assessment Objectives targeted by the question).
- Not written with sufficient clarity or accuracy to make meaning and argument coherent.
- Not showing an adequate knowledge of the text and/or not showing sufficient evidence of skills and understanding required.

Section 3: History

For each year a sample question relating to European history is provided for comparison. The 2008 question is taken from an AS-level paper as this topic was covered in the first year of A-level study.

June 1951
Paper 4

Question

15. What claims has Napoleon I to be regarded as a military leader of genius?

Marking guidance

No formal guidance was provided. Examiners relied on experience and comparator scripts that benchmarked performance at different grades to assess responses.

June 1970
Paper 5

Question

21. Discuss the merit and faults of Napoleon either as a military commander or as the ruler of France.

Marking guidance

Marking schemes were provided. These were basic and allowed considerable freedom to reward original and innovative responses. Comparator essays and the examiner's team leader were the main point of reference.

June 1990
Paper 13

Question

4. Examine the view that Napoleon I gave France order at the expense of liberty.

Marking guidance

Examiners were instructed to assess candidates on their ability to demonstrate:

- The ability to make effective use of relevant factual knowledge to demonstrate an understanding of a historical period or periods in outline and of particular topics in depth.
- The ability to evaluate and interpret source material as historical evidence and to demonstrate facility in its use.
- The ability to distinguish and assess different approaches to, interpretations of, and opinions about the past.
- The ability to express awareness of change and continuity in the past.
- The ability to present a clear, concise, logical and relevant argument.

Additional guidance was provided on what a candidate might cover in his or her responses.

June 2000
Paper 14

Question

43. 'He preferred conquest to peace.' Is this a fair comment on Napoleon's I's conduct of foreign policy?

Marking guidance

Examiners were advised to award marks in line with the following guidance:

The key issue is the conduct by Napoleon I of foreign policy. There should be little overlap with the previous question, even if candidates do not limit their arguments to his rule as Emperor (the question refers to Napoleon I). Examiners will allow a discussion of the period before 1804, but arguments which begin at this point will be equally valid. Candidates can discuss the War of the Third Coalition (1805-17) which saw the victories of Austerlitz and Jena, with Russia being forced to the Treaty of Tilsit. The Peninsula War, the resumed campaign against Austria and the fatal invasion of Russia can be examined. Some essays might discuss the significance of the Hundred Days, but this should not be a major issue and can be omitted without affecting the awarded mark. The most successful candidates will also consider other aspects of foreign policy, such as the implementation of the Continental System (Berlin and Milan Decrees) or his use of relatives to govern conquered and dependent states, Holland, Naples, Spain, Westphalia. Most candidates will probably agree unreservedly with the quotation but candidates should be given high credit when they consider the extent to which alternatives explanations might be defensible. This will require an analysis of his motives and of his methods, for example in organising the imperial empire. The aggressive aspect of the invasion of Russia is evident, but Napoleon resented Alexander I's refusal to implement the Continental System and alleged personal sights. How far was foreign policy intended to promote the ideals of the revolution? How far was it seen as a means to defend the empire? Vague arguments and very limited knowledge, with perhaps an understanding of only the 1812 Russian campaign will lead to marks below 11. 11-13 or 14-15 can be awarded for basically accurate and relevant narratives which show a satisfactory understanding of the most important developments in Napoleon's foreign policy. 16-17 will require some analysis of his motives and methods although the analysis will be uneven. A few excellent descriptions might deserve a mark in this band. 19+ answer will be thorough in their analysis of issues but they will not show the flexibility of the 21-25 essays.

Examiners were instructed to assess candidates on their ability to demonstrate:

- The ability to make effective use of relevant factual knowledge to demonstrate an understanding of a historical period or periods in outline and of particular topics in depth.
- The ability to evaluate and interpret source material as historical evidence and to demonstrate facility in its use.
- The ability to distinguish and assess different approaches to, interpretations of, and opinions about the past.
- The ability to express awareness of change and continuity in the past.
- The ability to present a clear, concise, logical and relevant argument.

June 2008
Period Studies European and World History 1789-1989

Question

2. a) 'Napoleon's main aim in domestic policy was to win the support of the middle classes.'
How far do you agree with this view of the Consulate (1799-1804)?

Marking guidance

Examiners were advised to award marks in line with the following guidance:

No set answer is looked for but candidates will need to address the question.

Key points: Broad interpretations of the term 'middle classes' are acceptable – some may refer strictly to the 'bourgeoisie' and perhaps distinguish the group from the nobles or identify them as part of the 'notables'. Others may see the term as a euphemism for the term 'notables'. What matters is the way the candidate applies what he or she knows in relation to the question focus.

In favour of the focus candidates may refer to: Constitutional and administrative reforms gave prominence to notables/middle classes locally and nationally as mayors, prefects, legislators and tribunes etc. Education reforms favoured able sons of notables/middle classes. Legal reforms and Concordat guaranteed notables in possession of lands acquired during revolution (biens nationaux) and property rights generally, emphasis on order welcomed by notables/middle classes, economic policy brought stability, careers open to talents etc.

To balance this, candidates may point to other aims: priority was Napoleon and security in power, if that meant appeasing notables/middle classes he would do so, but not to extent of allowing freedom of press or speech or effective middle class democracy (constitutions). Notables/middle classes preferred private education to the indoctrination involved in the Lycées.

Alternative explanations are possible and examiners must be open to alternative approaches. If in doubt, consult your Team Leader.

Markers were instructed to award marks (to a maximum of 45) as follows:

36-45
The response evaluates the key issues and deals with the perspective(s) in the question convincingly and relevantly. The answer is successful in showing a high level of understanding. The answer focuses on explanation rather than description or narrative. The quality of historical knowledge supporting the argument is sound and is communicated in a clear and effective manner. The answer is well organised. The writing shows accuracy in grammar, punctuation and spelling.

At the higher level (40-45), responses will effectively justify why one factor is the most important or the main factor and will also explain why other factors are less important. There will be a sense of judgement in relation to the factors shown by discrimination between them in terms of type and nature of the factor. How factors are linked to each other will also be addressed.

At a lower level (36-39), responses will justify why one factor is the most important but the explanation of why others are less so will be less effective. There will be some attempt to classify and draw links between factors.

32-35
The response is mostly successful in evaluating the key issues in the question convincingly and relevantly. It develops most of the relevant aspects of the perspectives(s) in the question. The answer is successful in showing a high level of understanding. The answer focuses on explanation rather than description or narrative. The answer will deal with several factors will come to a judgement as to which was most important (ie 'How far...?' or 'To what extent...?' will be addressed). However, the reasoning will often be patchy and may be confined to a lengthy conclusion. Similarly the establishment of links between factors and their classification may not be extensive and, at the bottom of the Band, hardly present at all.

The quality of historical knowledge supporting the argument is sound and is communicated in a clear and effective manner. The answer is well organised. The writing shows accuracy in grammar, punctuation and spelling.

Marking guidance continued

27-31
The response is reasonably successful in evaluating key issues and in dealing with perspective(s) in the question convincingly and relevantly. The answer is reasonably successful in showing a good level of understanding. The answer tends to be descriptive or narrative in approach but the argument depends on some analysis. The quality of recall, selection and accuracy of historical knowledge, applied relevantly, is mostly sound and is communicated in a clear and effective manner. The organisation is uneven but there is a sustained argument.

The quality of historical knowledge supporting the argument is satisfactory and is communicated in a competent manner. The comments miss some points or are less satisfactory in terms of supporting historical knowledge. The response will recognise the need to deal with a number of factors and where the question demands it may well provide some very limited argument why one factor was more important than others. A list of factors will be dealt with and explained effectively but the linkages and any necessary explanation of most important will be slight and undeveloped. The writing generally shows accuracy in grammar, punctuation and spelling.

23-26
The response has some success in discussing some key issues and in dealing with some of perspective(s) in the question. The answer is descriptive or narrative in approach but there is some implicit analysis. The quality of historical knowledge supporting the argument is satisfactory and is communicated in a competent manner. The comments miss some points or are less satisfactory in terms of supporting historical knowledge. The organisation is uneven but the answer pursues an argument. The writing usually shows accuracy in grammar, punctuation and spelling but contains some careless errors.

18-22
The response discusses some key issues in the question but only at a very basic level. The answer shows some adequacy in its level of understanding and is descriptive or narrative in approach. The quality of historical knowledge supporting the argument is limited but is mostly communicated in a competent manner. The organisation is uneven. There is some irrelevance but most of the answer focuses on the question. The writing shows accuracy in grammar, punctuation and spelling but contains some frequent errors.

10-17
The response does not discuss the key issues in the question and shows little understanding of the perspective(s) in the question. The answer is inadequate in its level of understanding with poor description or narrative. The quality of historical knowledge is thin or significantly inaccurate. There is significant irrelevance. The answer is communicated in an incompetent manner. The organisation of the answer is very poor. The writing shows significant weaknesses in the accuracy of grammar, punctuation and spelling.

0-9
The response fails to discuss the key issues in the question and shows no understanding of the perspective(s) in the question. The answer is completely inadequate in its level of understanding. Historical knowledge is either absent or completely inaccurate or irrelevant. There is no organisation to the answer. The writing shows very major weaknesses in the accuracy of grammar, punctuation and spelling.

Section 4: Mathematics

For each year a sample mechanics question is provided for comparison. The 2008 question is taken from an AS-level paper as this topic was covered in the first year of A-level study.

June 1951
Paper 1

Question

3. Prove the formula $s = ut + ½\ at^2$ for uniformly accelerated motion in a straight line.

   The motion of a train between two stations A and B is in three stages. In the first stage the train starts from rest at A and moves with constant acceleration. In the second stage it moves with constant speed and in the last stage it has constant retardation and comes to rest at B. If the times taken over the three stages are in the ratio 6:15:4, show that the average speed is four-fifths of the maximum speed and that the distance travelled with constant speed is three-quarters of the distance AB.

Answer

3. Since the acceleration is uniform, for some fixed a (as given in the formula), $\frac{dv}{dt} = a$. On integrating, we find that $v = at + C_1$ for some constant C_1. We substitute $t = 0$ to identify C_1 as u, the initial velocity. Hence $v = u + at$. But $v = \frac{ds}{dt}$, so we may integrate again to get $s = \frac{1}{2}at^2 + ut + C_2$ for some constant C_2. If we take s to be the displacement from the initial position, we have $s = 0$ when $t = 0$, and hence $C_2 = 0$, and this gives the formula $s = ut + \frac{1}{2}at^2$.

   To solve the given problem, let the accelerations over the first and third sections be a and r respectively (so that $r < 0$, since it is a deceleration). Let the times over the 3 sections be t_1; t_2; t_3, and similarly the displacements and velocities at the end of the 3 sections are s_1; s_2; s_3 and v_1; v_2; v_3. Using the formulae we have derived above for velocity and displacement, we find that

   $s_1 = 0 \cdot t_1 + \frac{1}{2}a\ t_1^2$ and $v_1 = at_1$,

   $s_2 = v_1 \cdot t_2$ and $v_2 = v_1$,

   $s_3 = v_2 \cdot t_3 + \frac{1}{2}r\ t_3^2$ and $v_3 = v_2 + rt_3$.

   We are given the relationship between the times, and find that $t_2 = \frac{15}{6}t_1 = \frac{5}{2}t_1$ and $t_3 = \frac{4}{6}t_1 = \frac{2}{3}t_1$.

   Now the train is at rest at B, and so $v_3 = v_2 + rt_3 = at_1 + rt_3 = 0$. Hence $r = -a\frac{t_1}{t_3} = -\frac{3}{2}a$.

   We can now work out the total distance travelled and the time taken:

   Total distance $= \frac{1}{2}a\ t_1^2 + \frac{5}{2}a\ t_1^2 + \frac{2}{3}a\ t_1^2 + \frac{1}{2}r \cdot \frac{4}{9}t_1^2 = \frac{11}{3}a\ t_1^2 + \frac{2}{9}r\ t_1^2 = \frac{11}{3}a\ t_1^2 - \frac{1}{3}a\ t_1^2 = \frac{10}{3}a\ t_1^2$, and the total time $= t_1 + \frac{5}{2}t_1 + \frac{2}{3}t_1 = \frac{25}{6}t_1$.

   Therefore the average speed is $\frac{10}{3}a\ t_1^2 \div \frac{25}{6}t_1 = \frac{4}{5}at_1 = \frac{4}{5}v_2$ as required.

   Also, the distance travelled with constant speed is s_2, and $\frac{s_2}{s_1 + s_2 + s_3} = \frac{5}{2}a\ t_1^2 \div \frac{10}{3}a\ t_1^2 = \frac{15}{20} = \frac{3}{4}$ as required.

June 1970
Paper 2

Question

3. Three fixed buoys *A*, *B* and *C* form an equilateral triangle of side 8 kilometres. The buoy *B* is due east of *A* and the buoy *C* is to the north of the line *AB*. A steady current of speed 4 kilometres per hour flows from west to east. A motor-boat which has a top speed of 12 kilometres per hour in still water does the triangular journey *ABCA* at top speed. Find, graphically or otherwise, the time taken on each leg of the journey giving your answers in minutes.

..... [1, 5, 5]

Answer

3. 30 minutes, 50.584 minutes, 50.584 minutes

June 1990
Paper 2

Question

2. [In this question take the value of g to be 10 m s^{-2}.]

   From a point O on horizontal ground a particle is projected with speed 200 m s^{-1} at an angle of elevation α above the horizontal. The particle moves freely under gravity. The horizontal lower surface of a cloud is 500 m above the ground. Find the smallest value of α such that the particle would reach the cloud and, for this value of α, find the distance from O at which the particle would strike the ground. [6]

   It is given that $\alpha = 60°$. Find the length of time for which the particle is above the lower surface of the cloud. Find also the speed of the particle at the instant when it enters the cloud. [8]

Answer

2. Smallest value of $\alpha = 30°$; distance from O at this angle is 3464m

   28.284 seconds, 173.2 m s^{-1}

June 2000
Paper 2

Question

7. Two railway trucks *A* and *B* are moving in the same direction on the same straight horizontal track, and they collide. Truck *A* has mass 20,000 kg and truck *B* has mass 10,000 kg, and immediately before the collision their speeds are 1.5 m s^{-1} and 1m s^{-1} respectively. When the trucks collide they are automatically coupled together. Find the speed of the trucks immediately after they collide. [3]

   After they collide, a braking mechanism exerts a resisting force of magnitude 5000 N on the leading truck *B*, and the trucks slow down. Calculate

   i) the deceleration of the trucks [2]

   ii) the magnitude of the force exerted on the leading truck *B* by the second truck *A* while the trucks are decelerating. [2]

Answer and marking guidance

7. Equate total momentum before and after

   State or imply a correct equation 20000 X 1.5 + 10000 X 1 = (20000 + 10000)v

   Obtain answer $\frac{4}{3}$, or equivalent correctly

   i) State either 5000 = (±) 30000a or both of 5000 – P = (±)10000a and P = (±) 20000a

   Obtain answer (±) $\frac{1}{6}$, or equivalent, for the deceleration

   ii) Use a Newton II equation for one of the trucks with their numerical a (or numerical v and t) to find P

   Obtain answer (±)3333 $\frac{1}{3}$ or 3300 only

   [if g appears in the momentum equation deduct A1 but allow A1 for answer $\frac{4}{3}$ or equivalent.]

June 2008
Mechanics 1

Question

6. A model train travels along a straight track. At time t seconds after setting out from station A, the train has velocity v m s^{-1} and displacement x metres from A.

   It is given that for $0 \leq t \leq 7$

   $x = 0.01t^4 - 0.16t^3 + 0.72t^2$.

   After leaving A the train comes to instantaneous rest at station B.

   i) Express v in terms of t. Verify that when $t = 2$ the velocity of the train is 1.28 m s^{-1}. [3]

   ii) Express the acceleration of the train in terms of t, and hence show that when the acceleration of the train is zero $t^2 - 8t + 12 = 0$. [3]

   iii) Calculate the minimum value of v. [4]

   iv) Sketch the (t, v) graph for the train, and state the direction of motion of the train when it leaves B. [4]

   v) Calculate the distance AB. [2]

Answer and marking guidance

6. i) $x = 0.01t^4 - 0.16t^3 + 0.72t^2$.
   $v = dx/dt$
   $v = 0.04t^3 - 0.48t^2 + 1.44t$.
   $v(2)=1.28$ ms^{-1}

   ii) $a = dv/dt$
   $a = 0.12t^2 - 0.96t + 1.44$
   $t2 - 8t + 12 = 0$

   iii) $(t - 2)(t - 6) = 0$
   $t = 2$
   $t = 6$
   $v(6) = 0$ ms^{-1}

   iv) Direction of travel is away from A. Graph:
   • Starts at origin
   • Rises to single max, continues through single min
   • Minimum on t axis, non-linear graph

   v) $AB = 0.01x6^4 - 0.16x6^3 + 0.72x6^2$
   AB = 4.32 m

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