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CO-ORDINATED SCEINCES

Paper 0654/01
Multiple Choice

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20	**A**	40	**D**

General comments

At 71%, the mean of this paper was very good, with the mean score on Physics items being even higher. Teachers and candidates alike are to be congratulated for such good preparation.

Comments on specific questions

Not all items revealed things worth commenting on, especially as so many had such a high facility, but the following points are worth making.

Question 1

With 95% of candidates realising that the udder of a cow marks it out as a mammal, this question did little more than provide an encouraging welcome to the paper as a whole. It is difficult to follow the thought processes of the 3% who thought that the hoof was significant.

Question 4

The skill required here was to interpret a plan diagram which may not have been familiar to all candidates. The better candidates chose correctly, otherwise there was evidence of guesswork from the other 40%.

Question 11

It is, perhaps, a little surprising that candidates did not link menstruation with a decrease in thickness of the uterus wall with almost a third opting for the time at which the wall is beginning to gain in thickness. It was comforting to note that the question discriminated very well between able and less-able candidates.

Question 12

Genetics is traditionally difficult for a significant proportion of candidates and, in this particular case, the answer hinged on appreciating that the question asked for the likelihood of a heterozygous offspring. The answer required was 1 in 2 (**C**) rather than the more familiar 1 in 4 result (**B**) from a heterozygous cross. Despite this twist, 55% of candidates reasoned themselves to the correct conclusion.

Question 14

This discriminated extremely well. Amongst the lower-scoring candidates, responses **A** and **B** were both more popular than the key, **C**. This seems to indicate some real misunderstanding about the distinction between a mixture and a compound, as expressed by a chemical formula.

Question 18

Nearly half of the lower-scoring candidates chose **C**. This also seems to point to a lack of understanding abut the characteristic properties of metals in that they conduct electricity both when solid and when molten.

Question 19

This was found easy across the ability range.

Question 21

Some 31% of the lower-scoring candidates each chose responses **A** and **D** (the key). The implication is that the former candidates knew the 'direction' of the pH scale but were confused about the nature of ammonia.

Question 22

This was satisfactorily answered across the ability range. Taken with **Question 19** it might be concluded that tests for gases are well known. However, this conclusion is somewhat contradicted by the performance of **Question 25**. In this latter question, some 30% of the lower-scoring candidates went for responses **A** and **D** with only 26% choosing the key, **C**. No ready explanation comes to mind.

Question 26

This was found hard with poor discrimination. After the key **D**, the most popular answer across the ability range was **C**, but galvanizing a large object such as abridge girder is not very practical.

Question 27

This is the other question that the higher-scoring candidates found difficult. About a third of the candidates across the ability range chose **C**. Zinc (together with cadmium and mercury below it in the Periodic Table) does have a low melting point but zinc can be regarded as not being a typical transition element. It does not show variable valency because it has a complete *d*-shell and, in this respect, a distinction is often made between the terms '*d*-block element' and 'transition element', although the former term is not relevant to this level. From titanium to gold, melting points are usually at least as high at 1000°C. Quite apart from that, metals typically have basic oxides so it is not thought that the key would have been inaccessible.

Question 28

The vast majority chose units of volume, but over a third thought that mm^3 would be a suitable for the units on the measuring cylinder, presumably not realising just how small 100 mm^3 would be.

Questions 34 and 35

These were poorly done (both from the Light part of the syllabus), especially **34** where guesswork appeared to be the method for choosing the answer. **Question 35** was marginally better, but it really is inexcusable for a third of the candidates to be unable to identify angles of incidence and refraction.

Question 40

Half the candidates answered correctly and 82% realised the alpha-particles cannot penetrate 1 cm of aluminium, but over a third thought that they are negatively charged.

Paper 0654/02

Paper 2 (Core)

General comments

Most candidates were able to attempt most questions and often managed to write a considerable amount. Many gained good marks on one question but then gained few marks elsewhere. **Questions 5** and **7** were very poorly answered by many candidates. Many marks were lost by a lack of precision in giving answers. Although it appeared that candidates often knew the substance of the question, they gave answers, which were very vague. There was no evidence of candidates suffering from a shortage of time to complete the examination.

Comments on specific questions

Question 1

This question was generally well answered.

(a)(i) This was well answered by many candidates showing a good basic understanding.

(ii) Diagram E was felt to be very ambiguous, so candidates were not penalised for any answers involving diagram E. Many candidates only gave one answer for each, rather than list all the diagrams representing giant structures or simple molecules.

(b)(i) Many candidates knew the correct answer was 30 but predictably there were also many answers of 25 and 55.

(ii) Most candidates got this right.

(iii) There were few correct answers here. Much of the confusion was about the relative mass of the neutrons. Additionally many candidates seemed unaware that electrons had a negligible mass.

Question 2

This question was not well answered.

(a)(i) Only a minority of candidates knew about the role of cartilage and synovial fluid.

(ii) There were very few correct answers to this part.

(b) More candidates gained some credit in this part, although few scored full marks.

(c) Answers to this part lacked precision. Many candidates confused cholesterol with fat and were unable to explain how the arteries became blocked.

Question 3

The first parts of this question were often well answered showing good data-handling skills.

(a) Most candidates calculated this correctly, but there were also a surprising number of errors.

(b) Many candidates gained full marks here and many who still did not know the correct formula.

(c) Candidates generally gave an answer 10 times greater than their answer to part **(a)**, although some divided by ten instead.

(d) This calculation was not well answered.

(e) A number of candidates knew the correct formula but few were able to substitute in the correct numbers to get the correct answer.

(f) This part was poorly answered. Many candidates gave answers suggesting that the mass of the passengers probably was not the average mass.

(g)(i) Although a number of candidates realised that sound travels because of the air particles vibrating, few mentioned the idea of compressions and rarefactions.

(ii) Most candidates gained this mark. The most popular answer was light.

Answers: **(a)** 6000 kg; **(b)** 2 700 000; **(c)** 60 000; **(d)** 3 300 000 J; **(e)** 33s.

Question 4

(a)(i) Carbon dioxide was very well known.

(ii) A wide variety of possible acids was given here.

(iii) Although many candidates gained a mark for stating that carbon dioxide was evidence of limestone, few gave the chemical name for limestone as calcium carbonate.

(b) The idea of flame tests was not well known. Many candidates tried to answer in terms of hard water.

(c) There was a very disappointing level of correct answers for this part. Vague references to air pollution were very common.

Question 5

This question was very poorly answered.

(a) Very few candidates were able to give any of the possible correct answers.

(b) Very few candidates gained even one mark here. The ideas involved were not well known.

(c) Similarly the process of denitrification was not well known.

(d)(i) Although there were few references to root hairs, many candidates did gain at least one mark here.

(ii) Most candidates correctly answered xylem, although there was a sizeable minority of answers of phloem.

Question 6

Many candidates gained marks on a variety of parts of this question, although there were few, who gained high marks overall.

(a)(i) Most candidates failed to recognise friction as the cause and there was a worrying number of references to positive electrons.

(ii) Many candidates gained at least one mark here. The idea that like charges repel was not clearly expressed by many candidates.

(iii) Lack of movement of the balloon was often wrongly explained in terms of the stiffness of the wire.

(b)(i) Although many candidates scored one mark here for reference to the fact that hot air is less dense (or usually lighter) than cold air, there were few references to expansion.

(ii) Prevention of absorbing heat from the sun to stop the balloon overheating was commonly mentioned rather than the correct response of reducing radiation from the balloon.

(c) This part was generally well answered with many candidates scoring at least 2 marks.

Question 7

This question was poorly answered.

(a)(i) Many candidates found it difficult to explain this.

(ii) Only the better candidates correctly identified glucose here. There did not seem to appear to be a common wrong answer.

(b)(i) Very few candidates understood why ethanol was used here. Many answered in terms of reactivity or merely stated that it would work better.

(ii) The responses from many candidates here suggested that they had never seen simple chromatography experiments carried out.

(iii) This lack of experience of chromatography experiments was highlighted again here with few candidates realising that there were a number of components in the coloured material. Even fewer specified four components.

Question 8

This question was quite well answered. Many candidates found some parts of this question, which they could answer correctly.

(a)(i) Most candidates knew one or two of the correct three answers, but all three were needed for the mark.

(ii) Fat was fairly well known as the energy store within the body.

(b)(i) Some candidates knew that the hormone was insulin. There was no other frequently given wrong answer.

(ii) More candidates knew that the pancreas was the organ secreting the hormone.

(c)(i) Many candidates used the diagram to work out that red blood cells were involved. However few gave an answer, which gained any credit.

(ii) Although almost all the candidates wrote an answer to this part, few mentioned either anaerobic respiration or the production of lactic acid.

Question 9

(a) Only a few candidates appreciated that atoms were splitting and even fewer that it was actually the nuclei, which split.

(b) Surprisingly few candidates were able to give the correct definition of an isotope.

(c) Many candidates seemed to realise what the question was asking and attempted to answer it. However, their answers were not concise enough to gain any credit.

(d) This part was relatively well answered. However, many candidates lost marks again due to the vagueness of their responses.

(e) Most candidates seemed unaware of any causes of background radiation.

(f) Most candidates offered an answer here, but most were again too vague to be given any credit. Other candidates often gave incorrect answers such as nuclear power was pollution free or that nuclear energy sources are renewable.

Question 10

This question was well answered.

(a)(i) Some candidates misunderstood this question, giving an answer of "gives out heat" rather than a direct observation such as the flask becomes warmer.

(ii) Only the better candidates knew the correct word equation.

(iii) The test for hydrogen was well known.

(b)(i) Many candidates got the correct answer here, but there were also a lot of answers of 11 or 11.1 minutes, presumably because the graph finished at this time.

(ii) Most graphs drawn were just above the given line for the entire length.

(iii) Many candidates gained at least a mark here. The idea of surface area altering the rate of a reaction was quite well known. Few candidates however were able to explain why the volume of gas produced remained the same.

Answer: **(b)(i)** 8 minutes.

Question 11

(a) Only the best candidates gained full marks here, although most candidates managed at least one mark.

(b) The commonest answer was light.

(c)(i) Many candidates correctly stated that the answer was light. However phototropism was commonly given.

(ii) Most candidates appreciated that light was needed for photosynthesis, but few appreciated that the plant moved to obtain more light.

Paper 0654/03
Paper 3 (Extended)

General comments

This was the first examination using the new assessment pattern, in which candidates are entered either for Paper 2 or Paper 3. This paper is now designed to allow grades of A* to G to be awarded, although its main purpose is to discriminate between candidates achieving grades A* to D. The paper was, therefore, more accessible than in previous years. As has always been the case, some questions tested material from the core syllabus, while other questions or parts of questions tested supplement material. Some of these proved very difficult even for the better candidates.

In general it appeared that candidates had been entered appropriately and almost all candidates managed to score at least 20 marks or more.

Comments on specific questions

Question 1

This question appeared to be achieving its intended purpose, which was to give candidates a 'friendly' start to the paper, whilst still testing skills from the supplement of the syllabus (designing a key).

(a) Candidates were given the first pair of statements to help them to write subsequent ones. Marks were awarded for using pairs of statements, choosing ones that could actually be used (so 'long ears/short ears' was not acceptable as you would not be able to decide if you had only one animal in front of you), for producing a key that worked and for doing this in four pairs of statements. Most candidates scored either 3 or 4 on this.

(b) This was answered correctly by almost all candidates.

(c)(i) This part of the question was a little more demanding than **(a)**, but most candidates were able to choose the correct descriptions from within the paragraph. However, those who simply copied the statement 'lays a single egg in a nest' did not gain credit, as this implies that laying two eggs, or not in a nest, could still be a feature of mammals.

(ii) Here again, the majority of candidates had no difficulty in picking out the two relevant descriptions.

Question 2

(a) Most answers gave an example of an electromagnetic wave and a relevant function. The most common incorrect answer was sound waves.

(b) Acceptable responses included their speed, that they were transverse waves or that they could travel through a vacuum.

(c) Once again this was an accessible question for all but the weakest candidates. The majority were able to explain that electrons, with a negative charge, would build up on the screen and attract positively charged particles. Better candidates described the induction of charge on the dust particles. Even weaker candidates were generally able to mention that static electricity was involved, for which one mark was available.

(d)(i) It was surprisingly rare to award both marks here. Many candidates incorrectly included yellow in their answers.

(ii) This was very well answered.

Question 3

This question proved much harder than the two that preceded it, and it discriminated well between different levels of performance.

(a) This question asked about a property that would make an alloy 'particularly suitable for making aircraft parts', but many candidates failed to appreciate this and simply explained why alloys are less malleable than pure metals, often with excellent but irrelevant diagrams. The most frequent correct answers suggested that the alloy should be lightweight, which could decrease the weight of the aircraft and so conserve fuel.

(b)(i) Whilst many correctly gave the formula of $MgCl_2$, fewer were able to explain this in terms of the balance of charge between a positively charged magnesium ion and two negatively charged chloride ions.

(ii) This, too, caused difficulties for many candidates. Better answers mentioned that charge was carried through the electrolyte by ions, which are free to move when molten but not in solid form. Some saw a different point of view and explained that, if the magnesium chloride were in solution, then hydrogen and not magnesium would be collected at the cathode. Weaker candidates, however, thought that the current was carried through the electrolyte by electrons.

(c) This was well-answered by better candidates, who understood that the greater the separation between two metals in the reactivity series, the larger the voltage produced. As might be expected, many candidates showed no knowledge of this concept, and guessed that metal X would be more reactive than iron because 'a larger current flows through it'.

Question 4

Answers to this question varied from excellent to very poor indeed.

(a) This was not answered well. Only a few of the better candidates were able to explain the shape of the rising curve between A and B. They wrote about the enzyme 'working faster and faster until it reaches its optimum', but it was rare to see a real *explanation* rather than a *description*. The best answers explained that the molecules involved (enzyme and lactose) gain kinetic energy as temperature rises, so that there are more frequent (and more energetic) collisions between them. This is an area where it is important that biology teaching and chemistry teaching are brought together, so that candidates can use concepts learned in one area of science to explain facts learned in another.

They did a little better in explaining **B** to **C**, as most knew that the enzyme would be denatured by high temperatures. There are still a few who think that enzymes are 'killed' as temperature rises.

Weaker candidates wrote their answers as though the *x* axis showed time. This resulted in answers such as 'by 90, the reaction has finished and the lactose is all used up.'.

(b) The curves drawn were very varied. The Examiners were looking for a curve that followed approximately the same shape as the one already given (roughly exponential rise, then sharp fall) with an optimum somewhere between 30 and 40ºC.

(c)(i) This question required understanding of the way that enzymes work, and on the whole was answered well. The use of the term 'catalyst' was credited, together with some comment that the enzyme was 'not used up' in the reaction, or that it 'stayed the same'.

(ii) This, too, was quite well answered. Many appreciated that, unless the enzymes were immobilised, there would be a problem in removing the lactase from the milk product. There were also numerous weak answers, such as suggesting that the beads would have a larger surface area that could react with the substrate. Some simply gave the answer they had already been given, that is the advantage of being able to reuse the beads.

(d) Acceptable points included a mention of the small intestine or ileum, villi and diffusion (or active transport).

Question 5

As is often the case with questions based on calculations, better candidates gave perfect answers while others scored 0.

(a) Most knew $v = f\lambda$, and were able to manipulate the formula so that they could calculate wavelength. A common error was to give the units with the answer as λ rather than m.

(b)(i) Again, this was mostly done well, although some candidates failed to include the distance there and back in their calculation, and so lost one of the three available marks.

(c) While most stated that X-rays might harm the mother or baby, it was not often possible to give a second mark for supporting this with the idea that X-rays are ionising while sound waves are not. Commonly-seen suggestions were that babies do not have bones so that you would not be able to see them with X-rays, or that X-rays would go right through the baby while sound waves would bounce back.

(d) This was usually answered correctly.

Answers: **(a)** 0.03 m; **(b)** 1.6 s.

Question 6

Most candidates were able to do fairly well on the early parts of this question, but once they arrived at the calculation only a very few could give relevant answers.

(a)(i) This was a relatively accessible question, and most scored both marks.

(ii) This explanation was often well done, and most candidates appreciated that only some solids would be stopped by the filter. Credit was given for mentioning substances in solution, and bacteria, and explaining that the former could be toxic while the latter might cause disease.

(iii) The expected answer was 'chlorination' and this was frequently seen. Spelling could cause difficulties, and 'chlorification' was allowed so long as it was obviously not 'clarification'.

(b)(i) Only relatively few candidates were able to explain that the calcium ions were removed from the water as the calcium carbonate precipitated and formed scale.

(ii) Some candidates answered this entirely correctly in only a few lines, while others used the whole page to do various calculations, usually failing to point the Examiner to the ones that they would like to be marked. It was quite often possible to give a mark for correctly calculating the RMM of calcium carbonate, even when everything else had gone awry. Examiners tried hard to follow the candidates' working, in case another mark could be found somewhere, but were frequently defeated by the complete lack of logical sequence within the numerous pieces of arithmetic.

Answer: **(b)(ii)** 0.005 mol dm^{-3}.

Question 7

This should have been a very accessible question, and it was a little surprising to see so many candidates failing to achieve full marks.

(a)(i) Most correctly calculated that ammeters A_1 and A_2 would read 2.0A. A_5, however, was often given as 1.5A rather than 0.5A.

(ii) This was usually answered correctly, although some candidates did quite long and involved calculations before arriving at the correct answer. A few spoiled an otherwise correct response by adding an incorrect unit, most commonly A.

(b) This proved slightly more difficult than **(a)**, although most were able to give 6 V for both readings.

(c) The idea that water is a conductor and that a person might be electrocuted was correctly given in most answers.

Answers: **(a)(ii)** 2; **(b)** both 6 V.

Question 8

This question provided a very wide range of marks. There was no part that could be answered purely by recalling facts, and candidates who found difficulty in applying their knowledge in new situations struggled to earn more than two or three marks.

(a)(i) This was not answered well. The Examiners were looking for the idea that the student was keeping a possible variable constant, or trying to make his experiment a 'fair test'. Credit was also given for suggesting that the leaves near the end of the branch might be a different age from those near the trunk (many thought that the newest leaves would be found nearest to the trunk, but this was not penalised) or that those at the end of the branch might get more sunlight.

(ii) This part of the question was very well answered, and almost all gained at least one mark here, frequently two.

(iii) Better candidates explained that, as the leaves were all on the same tree, they would all have the same genes.

(b)(i) The meaning of 'mutation' was quite well known, although some candidates gave answers that made no mention of genes, chromosomes or DNA. Some wrongly suggested that mutation occurred 'to make an organism better adapted to its environment.'

(ii) Some very surprising ideas surfaced in response to this part of the question. Quite a few suggested that the mutation would pass from cell to cell by diffusion, or that nearby cells would be 'infected' by it as it spread throughout the tree. The expected answer was that the cell containing the mutation could divide to form new cells, each of which would contain the same mutated gene.

(iii) Although a few answers tried to answer this in terms of a nutrient shortage (for example magnesium or nitrogen), the majority understood that it related to the chlorophyll content of the leaves. However, not all were able to give a clear and logical explanation. Marks were awarded for a statement that the yellow leaves had less chlorophyll (or chloroplasts), meaning that less light could be absorbed so that less photosynthesis could take place. This in turn would mean a lack of 'food' needed for growth.

Question 9

While parts **(a)** and **(c)** were well answered on the whole, it was rare to see good responses to **(b)** or **(d)**.

(a)(i) Candidates needed to state that a hydrocarbon has molecules containing hydrogen and carbon *only*. Some wrongly stated that it contains hydrogen and carbon molecules.

(ii) This was almost always answered correctly.

(iii) This, too, was usually answered well.

(b) This was not well done. Some candidates were able to explain that, as gasoline contains smaller molecules than diesel, there are less strong *intermolecular* forces between them and that this means that less energy is needed to separate the molecules (thus a low boiling point) and it is easier to drag the molecules past each other (therefore low viscosity). Many gave a general answer rather than relating it to gasoline and diesel or the data in the table. Many described the breaking of bonds between the atoms in the molecules. This is not an easy concept, and it appeared to stretch even the very best candidates.

(c)(i) Most could state that an unsaturated hydrocarbon has a (carbon-carbon) double bond.

(ii) The test for an unsaturated hydrocarbon is generally well known, and fewer candidates are now saying that bromine water goes 'clear', rather than 'colourless'.

(iii) Some candidates correctly suggested that ethene has more valuable uses and therefore has far greater demand as a reactant, for example in the production of polyethene. Many, however, answered in terms of non-renewable fuels, which is not relevant here.

(d) In general, the production of ethanol from ethene is not well known. Marks were awarded for saying that heat or high pressure are used, in the presence of a catalyst, as ethene is reacted with steam, but all of this was only rarely seen in answers. However, many did manage to use the information they had been given to write an equation.

Question 10

Better candidates scored highly here, and marks of 10 were not infrequent. Nevertheless, there were still many incomplete or wrong responses.

(a) Most answers were correct, and most could clearly explain that silver is the best conductor because the lowest voltage is required to pass this current through it. A significant minority chose steel.

(b) This was usually correct, although some candidates did not know the unit of resistance.

(c) The correct answer, steel, was the one most commonly seen, although all of the other three were given by some candidates.

(ii) Where a formula for power was known, the calculation was normally carried out correctly. Many candidates, however, did not know a relevant formula or could not give the correct unit.

(d) This was well done by many. They were able to pick out relevant data from the table, and discuss the pros and cons of both aluminium and steel. One common error was to use the term 'resistance' to mean 'strength', which resulted in some confusion.

Answers: **(b)** 1.75 Ω; **(c)** 19.2 W.

Paper 0654/04
Coursework

General comments

Nature of tasks set by Centres

A pleasing number of Centres submitted coursework for the June examination. Most have provided coursework in previous years and have acted on advice given. In most Centres all the tasks set were appropriate to the requirements of the syllabus and the competence of the candidates. In only one Centre was there some minor confusion about a few tasks. The standard of candidates' work was comparable with previous years. Candidates' work covered the whole mark range with some Centres achieving some very high marks.

Teacher's application of assessment criteria

In nearly all Centres the assessment criteria were understood and applied well for all of their activities. Only one Centre (new to the scheme) tried to assess both skill C1 and C4 in the same investigation. Advice has been given to help the Centre avoid confusion in future.

Recording of marks and teacher's annotation

Following suggestions made encouraging the use of annotation on candidates' scripts many more Centres are using this technique to indicate or justify marks awarded. There is still scope for further improvement with some Centres writing comprehensive summaries but not indicating the point at which the mark was awarded. Tick lists remain popular with particularly skill C1. Many Centres have developed very comprehensive recording systems.

Good practice

Some Centres make very useful comments about individual candidate's performance on a summary sheet. Many Centres have developed a booklet of tasks and dedicated assessment criteria.

One Centre introduced spreadsheet format to summaries all candidates' marks across all assessments.

Paper 0654/05
Practical Test

General comments

Although the paper was of a similar standard to former years and the overall standard of performance was very satisfactory, there were no candidates with very high marks. A small number of Centres experienced a problem with the preparation of the leaf samples. The Examiners were able to take this into consideration when marking **Question 1**. Whilst comments are welcome concerning difficulties one or two comments seemed very minor e.g. why was the container in **Question 2** described as a plastic cup, the use of spill rather than splint and the lack of provision of a small measuring cylinder for **Question 3**. These reports have indicated many times before that candidates are expected to pour a small volume of liquid without the use of a measuring cylinder. If such is required, the instructions will indicate accordingly. The mark scheme worked well and produced a good spread of marks. There was no evidence that the time was insufficient. Most Supervisors completed their own set of results, a task that is invaluable to the Examiners.

Comments on specific questions

Question 1

Many candidates treated the drawing of the specimens as a trivial requirement and consequently lost unnecessary marks. Drawings should be large, neat and well labelled. A surprising number had no labels whatsoever. Some presumably mixed up the two leaf sections, showing specimen **A** as the one containing starch. As long as the results matched those in **(a)**, marks were awarded. Similarly marks in **(c)** were allowed. A reasonable number failed to obtain any reaction with iodine at all. The response 'a colour change' was not allowed. It was necessary to state that parts of leaf **B** showed a blue/black colour. Two marks were allocated to **(c)(ii)** although very few scored both. Little or no attention was paid to the explanation. The most common omission was a reference to the fact that chlorophyll is needed for making starch. Part **(d)** was often poorly answered, many candidates could only score one mark from the three available. Few appreciated the fact that rinsing with water made the leaf flexible. Most thought it was just to wash away the alcohol. There is nothing unusual in the procedure required for carrying out this experiment and it was therefore somewhat surprising to find so many poor responses. Some thought iodine would be used in part **(e)** although many correctly named Benedict's solution. The commonest error was to omit reference to heating the mixture to obtain the colour change. The last part of the question was usually well answered.

Question 2

As so often the case, candidates do not show an appreciation of accuracy in measurement. It is necessary to indicate that it is possible to measure, using a standard rule, to the nearest millimetre. Therefore, 10.0 cm is required and not just the figure 10. The Supervisor's result was important here and unless told otherwise, the Examiners assumed that all candidates used similar plastic cups. However, the recorded volumes varied greatly and there were some careless attempts to measure accurately. The recorded value was expected to be within 0.4 mm of the Supervisor's value. Some tried to calculate the volume from the dimensions of the cup, usually arriving at an absurd answer. A significant number recorded the distance, **d**, in cm and lost a mark, whilst a small number appeared to manufacture the values of **d**.

Graphs were generally very good with correct plotting and almost always a straight line. Although the correct line would be a curve, a straight line was requested for simplicity. Not surprisingly, many failed to read through what was required and found that the volume when **d** = 0 could not be read. Unless a viable alternative method was used two marks were lost. Part **(d)** did not discriminate particularly well. Candidates either knew how do perform the experiment correctly or not. Many thought a beaker was acceptable as the measuring device in which case only one mark could be scored. Even if a beaker is marked, it is a most inaccurate way of measuring a volume, particularly when a measuring cylinder is provided.

Question 3

Very few candidates indeed carried out the instruction as written in part **(a)**. Heating strongly is exactly what it says. Strong heat on solid **A** causes charring, release of carbon dioxide and considerable amounts of an inflammable gas. Whilst a small number stated the solid became brown (few said black), there were very few who produced evidence of an inflammable gas. It is good practice to test for a gas several times during the heating process as solids decompose at very different temperatures. Even the recognition of carbon dioxide was not as obvious as it should have been. More detected the carbon dioxide in **(b)** although it was clear that a good number added the lime-water to the tube, even recording that the tube cracked! If a lighted spill is extinguished, the answer 'no reaction' is incorrect. Part **(c)(i)** produced the usual large number who think that clear is the same as colourless. The former did not score, neither did the statement that **X** disappeared or **X** dissolved. The colour of UI paper was usually acceptable but a pH number greater than four was thought to be too high. It was not necessary to conclude a weak acid although a good number did. A small number thought **A** to produce an alkaline solution. A solution of **B** should produce a weakly alkaline reaction although many decided it was neutral. The majority scored the mark for effervescence or its equivalent in **(e)** although an alternative answer was to observe a fall in temperature. Part **(f)** was either well done or very badly done. In many cases it was left blank. The main criticism was the lack of quality diagrams. Often there was no attention to the correct use of bungs or the sealing of tubes that should not have been sealed. Many thought that just bubbling the gas into water would somehow measure the volume of gas. One candidate thought it could not be answered as gases do not have volumes!

Paper 0654/06

Alternative to Practical

General comments

As usual, some candidates reached a very commendable standard in this examination, but many entrants showed that they had a lack of experience in laboratory work. The Examiners always try to ensure that the wording of the questions is simple and that sentence construction is not complex. In spite of this, too many candidates seemed to find the descriptions of the experiments very hard to understand; coupled to their ignorance of laboratory apparatus and procedures, this meant that their scores were poor. A praiseworthy aspect of the candidates' work was the even spread of the marks gained in the three disciplines, biology, chemistry and physics.

Comments on specific questions

Question 1

The contrast between the starch content of leaves kept in light and dark conditions was the basis of this question.

(a) This was often well done, and neat diagrams of the leaf strips were drawn and labelled. The word "variegated" was sometimes unknown, but this should not have prevented candidates from labelling the areas containing chlorophyll. Occasionally, the whole leaf was drawn, but the correct labelling still earned one mark.

(b) The colours shown by iodine (brown/yellow) and starch with iodine (black/blue) were sometimes unknown. This revealed that the experiment had not been done, or seen, by the candidate.

(c)(i) Leaf A contained no starch, therefore had not been able to photosynthesise and store starch; some candidates added that the starch previously stored had been used up, but this point was not necessary to earn the two marks.

(ii) Areas containing starch, and the green areas shown in Fig. 1.1, were identical. This earned one mark. The second mark was gained by the candidate who mentioned that chlorophyll enables starch formation to proceed. No details of the function of chlorophyll were required; this was often not known and a minority of candidates wrote that chlorophyll was formed by the action of sunlight.

Question 2

The meter reading and graph plotting in this question was deliberately kept simple, in contrast to **Question 6** where a much harder graph plotting exercise was set. The question explored the change in current passing through a lamp as the resistance of the circuit was lowered.

(a) Most candidates achieved all three marks in reading the ammeter and voltmeter dials.

(b) The graph was already shown with the labelling and scales of the axes. Most candidates successfully plotted the two points on the graph and drew a line: the Examiners allowed either a curved line plotted through the points, or a "best straight line" to be drawn. No penalty was incurred if the line did not pass through the origin, but the shape of the line affected the answers to and the marking of part **(d)**.

(c)(i) The idea of electrical resistance is a difficult one, so it is not surprising that a large proportion of candidates incorrectly wrote that the brightness of the bulb decreased when the resistance was decreased. Others correctly stated that the current would increase when the resistance is lowered but failed to answer the question.

(ii) Experience of using a low voltage electrical circuit almost inevitably includes the "blowing" of the bulb when too great a current is passed. Some candidates also suggested that a fuse in the circuit might have melted, which was accepted as an answer here, but most candidates did not realise what could interrupt the flow of electricity through the circuit. Some, having wrongly answered the first question, wrote that the resistance was now so high that no current can flow.

(d) Ohm's Law can be illustrated in the laboratory by the drawing of a graph of **V** against **I** to show that it is a straight line through the origin. If the candidate drew a straight line for **(b)**, the answer that the bulb obeyed Ohm's Law, because the graph was a straight line, was accepted. Just a few candidates knew that the resistance of a conductor increases with temperature, so the bulb does not obey the Law, but this information was not necessary to gain the mark. Various relationships were stated for current, voltage and resistance. The words "inversely proportional" were used for current and voltage, and the words "proportional" with resistance and current, showing that these concepts are poorly understood both in a mathematical and in a physics context.

Question 3

This question took the candidates through the process of preparing a salt using a metal and acid, but with some complications so that a quantitative exercise was involved.

(a) The scales were to be read ascending, but alas, a few candidates read the balance windows in the question the wrong way up. As well as this, the first decimal place was expected to be included in the mass of the beaker and copper, so that it was 60.0 g not merely 60 g.

(b) Some candidates wrote about the "pH" of the gas being lower than 7, but the Examiners wanted the change in colour of litmus paper from blue to red, or of Universal Indicator paper to red, as the experimental observation showing that a gas is acid. Answers describing bubbling the gas through indicator were accepted if the correct colour change was mentioned.

(c) This was a hard mark, for the balance reading had to be correct and then a subtraction made from the mass of the beaker + copper at first, to find the mass of the copper, 3.2 g, that had been used up. A commendable proportion of candidates achieved this mark. If this mass was worked out, then used in a further incorrect calculation, the mark was awarded.

(d) Some candidates incorrectly interpreted the information that "copper(II) nitrate crystals decompose if they are heated" to mean that the solution could not be evaporated by boiling it. However, they could obtain one of the two marks by suggesting that leaving in sunlight or in the air would evaporate the solution. There were some good descriptions of the usual way to obtain crystals of a salt by partial evaporation and then cooling, and some better candidates wrote about the use of a boiling water bath. The poorer candidates described filtering to remove crystals from the solution.

(e) This last weighing was rather more straightforward, and many candidates earned the two marks, finding that 9.5 g of copper nitrate crystals had been formed.

(f) The student making the copper(II) nitrate crystals would not have achieved a good yield if the advice of many candidates had been followed! However, the question dropped heavy hints about possible reasons for a low yield, such as decomposition of the salt due to heating during crystallisation and the loss of some of the water of crystallisation. A few candidates also mentioned that the student might have spilled the solution. Just a handful also pointed out that some of the copper nitrate was left in the solution after crystals had been obtained. The idea that crystals contain water of crystallisation was often poorly understood, and some candidates wrote that the crystals might have evaporated.

Question 4

The combustion of a foodstuff in air was used to simulate the release of energy during respiration. Many candidates gained high marks for this question.

(a) Candidates read the balance windows with no difficulty here, in contrast to the frequent errors in similar parts of **Question 3**.

(b) Here, some candidates interpreted each division in the thermometer scale as 0.1^{o}C, writing 40.2^{o}C and 30.7^{o}C for the temperatures. This was the most common error in this question.

(c)(i) The temperature rise was marked with errors carried forward, so that the marks were earned for the subtraction of 25^{o} from the answers to **(b)**.

(ii) Common errors in substitution into the given formula for calculating heat energy given out were: the use of 1g as the divisor rather than the 0.8g and 0.5 g from **(a)**; and the use of the actual temperatures rather than the temperature rise. A majority of candidates were able to write J or Joules as the unit. A few gave kJ as the unit, but omitted to divide by 1000.

(d) The correct answer, "respiration", was given by most candidates.

Question 5

This is the question about analytical chemistry that usually forms part of this examination; as usual, there was ignorance of these very basic procedures to test for gases, acid and alkali. The number of candidates scoring full marks in this question was very low.

(a) *Test 1*. What does limewater look like? Of course, some candidates wrote, it is yellow! This question caught out many candidates. Clear or transparent were accepted as correct descriptions.

In *Test 2*, "the flame was extinguished" was a signal to some candidates that hydrogen was present, since when hydrogen is burned by using a lighted splint, the flame goes out with a Pop! Candidates must ensure that the description of the test for hydrogen, mentioned above, is properly understood. When a gas does not support combustion, the presence of nitrogen or carbon dioxide is a possible conclusion; the absence of oxygen is another.

Test 3. Examiners were reminded that in a few countries, a Universal Indicator that does not conform to the colour changes of the BDH Universal Indicator is used. An effort was made to ensure that candidates who were familiar with this product were not penalised. In *Test 4*, only the final colour of the indicator, yellow or green-yellow, was marked.

(b) Most successful candidates drew diagrams of a vessel having a delivery tube leading either to a graduated syringe or to a graduated tube collecting gas over water. Many fanciful diagrams were drawn in poorer answers. Candidates who had never seen an experiment in which gas is collected over water or in a syringe failed to gain marks here.

Question 6

This question, like **Question 5**, corresponded to the question in the Practical Examination, Paper 5. The candidates were invited to find the volume of a drinking cup in cm^3 and then to add a measured number of grams of water to it, while it stood in water, until it sank. The two amounts should be approximately equal if the mass of the drinking cup is ignored, thus illustrating a statement shown at the beginning of the question, that "when the mass in g of a vessel placed in water is just greater than its volume in cm^3 it will sink."

(a) A dropper or pipette or even a burette can be used to place the final few drops of water in the full cup. A diagram, however poor, of a teat pipette, earned the mark. There were references to puppets here!

(b) A simple subtraction of the volume remaining in a measuring cylinder, from its full volume, gives the capacity of the cup, 147 cm^3. Some candidates gave the volume remaining as 100.3 cm^3. Others did not know what to do with this figure to find the volume held by the cup.

(c) A millimetre ruler is used to find, from a full-size diagram, the height of the cup standing out of the water after measured amounts of water have been added. Instead of using the ruler, some candidates guessed these heights; others tried to find them, more or less successfully, from the graph in part **(d)**.

(d)(i) The graph grid was shown with no labelling. The terms "horizontal" and "vertical", as in previous years, were often not known. In the table of data, Fig. 6.3, the volumes were given in the first column, so many candidates automatically plotted these on the vertical axis in contravention of the instruction. This meant that the extension of the graph to cut the horizontal axis did not show the volume in the cup at **h** = 0. There were some poorly drawn graphs. The vertical scale sometimes went up in increments of 6 or 4, which made plotting harder. Occasionally, the horizontal scale chosen did not allow for the extension of the line to the axis. Some candidates, having measured (or guessed) the answers to part **(c)**, found that the graph did not follow a straight line, but they did not bother to check their answers.

(ii) The expected answer for the volume in the cup at **h** = 0 was 147 cm^3, the same as the answer to **(b)**, but the mark was awarded for the correct reading from the candidate's graph.

(iii) The cup sank when **h** = 0, an easy answer.

(e) This was probably the hardest question in the paper. Candidates had to compare the mass in the cup when it sank, taken from the graph, with the volume of the cup. The expected answer was that the two are identical at 147 cm^3, so the statement at the head of the question is correct. However, if they were not identical, the candidate could earn the mark by pointing out this fact. A very few candidates did gain this mark.