IGCSE CO-ORDINATED SCIENCES

Paper 0654/01
Multiple Choice

Question Number	*Key*	*Question Number*	*Key*
1	**C**	21	**A**
2	**B**	22	**A**
3	**B**	23	**B**
4	**C**	24	**D**
5	**B**	25	**C**
6	**D**	26	**B**
7	**D**	27	**B**
8	**B**	28	**A**
9	**C**	29	**C**
10	**C**	30	**B**
11	**B**	31	**B**
12	**D**	32	**D**
13	**B**	33	**D**
14	**A**	34	**C**
15	**B**	35	**B**
16	**D**	36	**C**
17	**C**	37	**C**
18	**C**	38	**C**
19	**D**	39	**C**
20	**A**	40	**B**

General comments

The mean of this paper was 72%, which is very good. Even more commendable is the fact that the average facility for the Physics items was around 78%. Teachers and candidates alike are to be congratulated for such good preparation, especially on the Physics items. All the items have appeared on equivalent papers at this level, so the candidates who sat this paper were clearly well prepared.

Comments on individual questions

Biology questions

All questions fell within the compass of the ability of the candidates taking the paper, with questions fitting candidates at both ends of the ability range.

Question 1

Candidates may have been a little confused over whether the question referred to a socket into which the bone fits, or to a socket visible on the diagram. Those who correctly realised that it was the latter arrived at the correct answer, though a few of the better candidates, as a result of recognising the bone as the humorous which fits into a socket, followed the alternative route to the incorrect answer.

Question 2

Although this question tested, in an entirely acceptable way, the difference between plant and animal cells, it proved too easy a question for an almost perfectly understood area of the syllabus. With 98% offering the correct answer, unfortunately, it failed to make a valid contribution to the test.

Question 3

This question proved to be particularly difficult. Candidates should be aware that the very tip of the plant is the receptor, not the effector (a fact which escaped a quarter of them, including some of the better ones). There can be little doubt that this topic is one of the more hazy in the minds of candidates, particularly when 41% identified the sun as the effector.

Question 13

Again, this was a difficult question, with almost a third of candidates opting for nitrifying bacteria as those responsible for returning nitrogen to the air. The nitrogen cycle is traditionally a topic the facts of which candidates find difficulty remembering. The statistics would suggest that the better candidates knew the answer, the rest made rather hopeful guesses.

Chemistry question

Relatively little comment is called for with respect to the Chemistry questions and, where appropriate, attention is focused on the performance of the lower-scoring candidates.

Question 15

Was, in essence, a question of straightforward recall. However, the lower-scoring candidates only just managed to prefer the key, **B**, with response **C** a rather close ‘runner-up’.

Question 19

Had a relatively low overall facility but it discriminated well. The explanation of these statistics is that very nearly 40% of the lower-scoring candidates chose response **B** rather than the key, **D**. The question refers to the electrolysis of a concentrated aqueous solution and the ‘bullet point’ products ought to have identified sodium choride as the answer.

Question 20

It is perhaps surprising – with respect to the use of aqueous barium ions in testing for sulphate ions – that as many as 36% of the lower-scoring candidates chose response **C**.

Question 21

Had a satisfactory overall facility and it discriminated very well. These statistics are accounted for by the fact that a third of the lower-scoring candidates chose response **B**. This is, presumably, a simple lack of recall knowledge.

Question 25

Such direct questions on metal reactivity are now proving to be easy with resultant poor discrimination.

Physics questions

Amongst the Physics items, because of the good performance of the candidates, there are only a few points, which are worth highlighting.

Question 32 worked well, but a fifth of candidates answered **A**, presumably because the air gap does prevent some heat loss (but not by radiation).

Question 33 was the least well done item amongst the Physics questions, and it revealed that a lot of candidates are familiar with the definitions of wavelength (option **A**) and amplitude (option **C**), but not with that of wave speed.

Question 34 – whenever refraction questions are set at this level, large numbers of candidates show their ignorance, although candidates on this paper are usually better than most. Ray optics really does need careful study.

Question 35, Some candidates linked ability to hear the sound with loudness and therefore amplitude. They failed to spot that it would be too small an amplitude which would prevent the sound from being heard, not too large, as in **A**.

Question 39 showed that whilst most (but not all) were clear that alpha-particles would not get through the aluminium and that radio waves were not relevant, they were not so sure about the other two radiations.

Question 40, few were drawn to the distracters relating to the temperature at 12.00, which means that the vast majority had grasped the point of the question. Unfortunately, a third of them reasoned/guessed that the temperature had decreased, rather than increased. Nevertheless, it was pleasing to see how many were able to deal with a question, which required careful thinking.

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Paper 2

General comments

Most candidates were able to attempt most questions. Many gained good marks on one question but then gained few marks elsewhere. **Question 6** in particular was poorly answered by most candidates. **Questions 3**, **4** and **8** were generally well answered. Many marks were lost by a lack of precision in giving answers. Although it appeared that candidates often knew the answer to the question, their answers were very vague. Perhaps language difficulties played some part here, although the general level of English was good. Performance depended not only on scientific knowledge but also on the ability to fully understand the question. There was no evidence of candidates running short of time to complete the examination.

Comments on specific questions

Question 1

This question was not well answered.

(a) Many candidates correctly matched up the components and functions to gain at least one mark.

(b) Many answers here were very vague describing the movement of blood around the body. There were few references to the heart muscle contracting or to the role of the ventricles.

(c) (i) This was quite well answered. Phloem was predictably a common wrong answer.

(ii) This was not known by most candidates. There were a few references to transpiration. Few candidates referred to the loss of water by evaporation from the leaves and very few candidates could describe why the water moves up the xylem vessels.

Question 2

This question was poorly answered.

(a) (i) Many candidates realised that the kinetic energy of the molecules would decrease but most were unable to take this further and explain that the size of the balloon would be determined by the impacts of the particles on the wall of the balloon.

(ii) Again, many candidates knew that the particles would move faster, but were unable to explain why this would mean more would escape from the water and evaporate.

(b) There were few references to reduction in pressure, although many candidates appreciated that the skis would stop the skier sinking into the snow.

Question 3

All parts were fairly well understood, with some candidates gaining good marks. Good data handling skills were demonstrated in parts **(a)** and **(b)**

(a) (i) This part was well known. Most candidates answered correctly.

(ii) Most candidates knew that acid was required but a number thought that the acid would have pH of 14.

(b) Most candidates correctly predicted a temperature rise and recognised a neutralisation reaction but very few recognised that this was an exothermic reaction with the release of energy.

(c) Many candidates related the limewater test to the gas carbon dioxide. However, few candidates could connect the release of carbon dioxide to a carbonate.

Question 4

There were some good answers to this question.

(a) Many candidates correctly identified the sun as the source of the energy. A common wrong answer was the maize.

(b) Although most candidates knew that either cattle or humans were consumers, many failed to mention both.

(c) Most candidates knew that decomposers decomposed something, but few were able to describe the process or refer to the importance of it in terms of recycling.

(d) (i) Many candidates explained that digestion was the breaking down of large food molecules into smaller ones, but there was no real appreciation of what happened after this in terms of absorption.

(ii) Many candidates knew that amylase was involved, but few were able to specify where the amylase came from or what the products of the breakdown of starch would be.

(e) This was well answered by many candidates, who able to state both the type of food causing the problem and the result on the health of the consumers.

Question 5

(a) (i) The retina was not well known. The back of the eye was a common answer.

(ii) Very few candidates seemed to understand this. Only a few were able to give a suitable effector.

(b) Most candidates managed this to some extent. Many gained full marks. Some lost marks for not drawing straight lines or for not drawing lines from the lens. Arrows should also be attached to the rays.

(c) (i) Many candidates stated two of the three correct colours. Yellow was a popular wrong answer.

(ii) Very few candidates gave an answer referring to either the frequency or wavelength of the wave.

Question 6

This question was very poorly answered. Few candidates had any idea about parts **(a)** and **(b)**.

(a) This part was not well answered. There were many ways in which the candidates could have gained credit by describing something they knew about electrolysis. Few gave any sensible response. There were a number of candidates who managed to explain the function of an electrolyte.

(b) This part was not well answered. There were many ways in which the candidates could have gained credit by describing something they knew about sols and emulsions. Many candidates gave very vague answers, which did not answer the question.

(c) Whilst most candidates attempted this part, most answers were vaguely in terms of waves going up and down or backwards and forwards. There were few attempts to describe the differences in terms the need for a medium or the relative directions of the waves and vibration of medium.

Question 7

(a) This was well answered by many candidates. The least well-known part was the cervix.

(b) This was fairly well answered. Most candidates had a rough idea of what happened, but many were unable to use appropriate words.

(c) Most candidates lost marks here for suggesting that it was the umbilical rather than the placenta involved. Most candidates included some reference to the mother and therefore gained some credit.

(d) A number of candidates appreciated that there would be more particles, but the idea that these particles would collide with the tyre walls was not well known. Most answers explained that the particles would be closer together and therefore the pressure increased.

Question 8

Part **(a)** was well answered.

(a) (i) **T**here were many correct answers here.

(ii) This was also well known.

(iii) Candidates found this more difficult. Often they tried to describe one out of A and B rather than suggesting that it was A and B, and that it was because they were not accelerating.

(iv) This was well answered by the better candidates.

(b) Considering there were so many marking points available few candidates scored well on this. Perhaps they were **c**onfused as this part was about radioactivity and the rest of the question was about motion.

Question 9

There were some good answers to this question.

(a) (i) Potassium was the most common answer. Phosphorus was however often mentioned.

(ii) This was answered well by many candidates. Many candidates gained full marks and most gained at least one.

(b) Many candidates correctly suggested wheat, although only a large percentage of these explained their answer. Their explanation could have been written or shown on the table.

(c) (i) Few candidates had any idea that nitrogen was too unreactive to react.

(ii) Hydrogen was not well known. The common wrong answer was phosphorus.

(iii) 8 was the commonest answer although there were many alternative wrong answers.

(d) Few candidates managed to gain both marks here for stating that soil may be too acidic for crops to grow well and that lime neutralises the excess acid.

(e) The types of weathering were quite well known but the descriptions/explanations of these were less well known. Consequently many candidates only gained one mark here.

Question 10

(a) Hair or fur was well known.

(b) (i) The answer 'nucleus' was not well known.

(ii) The correct answer was all cells. The most common answer was sex cells.

(c) (i) Most candidates realised that high temperature affected the processes going on in the cells. Few mentioned that high temperature denatured enzymes or proteins or that enzymes worked best at a particular temperature.

(ii) Few candidates got this basic equation correct and not many gained one mark for getting one side of the word equation correct.

(iii) Few candidates gained even one mark here. The three marking points seemed totally inaccessible to most candidates.

Question 11

(a) Kinetic energy to electrical energy was probably the most popular answer but there were many wrong answers.

(b) Disappointingly, few candidates still understand this problem. The current needs to be lowered so that the energy losses will be reduced.

(c) (i) The better candidates managed the calculation and could correctly state the formula.

(ii) Again only the better candidates managed the calculation and could correctly state the formula.

(d) (i) This was well answered by many candidates who successfully connected the animal or plant origin with long length of time required

(ii) Coal, gas, oil and petroleum were all common correct answers.

Question 12

(a) Almost all candidates correctly identified paper as the fourth answer. The other answers were less well found especially glass as the first answer.

(b) (i) Carbon and hydrogen was not well known here.

(ii) The more able candidates managed to find one property which differed for the two fractions.

(c) (i) Few candidates knew the difference between saturated and unsaturated hydrocarbons. Indeed many got the definition back to front.

(ii) The idea that a catalyst speeded up a reaction was well known. The fact that it remained unchanged at the end of the reaction was less well known.

(iii) Very few candidates realised that if the catalyst was in smaller pieces that the surface area would be greater and that therefore the reaction would be quicker. Very few marks were awarded on this part.

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Paper 0654/03

Extended

General comments

The performances on this Paper covered a very wide range. Many candidates achieved marks well over 80 (out of 100), and showed an excellent knowledge and understanding of the facts and concepts in both the core and supplement of the syllabus. At the other end of the scale, there were a large number of candidates who appeared to be entirely unfamiliar with the supplement of the syllabus, and who struggled to earn more than 10 marks in the whole paper.

No one question proved especially difficult. Weaker candidates struggled with the calculations in **Question 2(b)(iii)** and **(iv)**, whilst the calculations in **Question 7(b)** and **(c)** were accessible to almost all. It was good to see most candidates giving good answers to some of the questions requiring extended writing, such as **Question 4(c)**, but almost all found **Question 3(b)(iii)** difficult.

Some candidates did not always read the question and answer what they were asked. For example, in **Question 1(b)**, many began their answer by describing how the blood *enters* the heart, and in **Question 9a** some gave the symbol and not the name, as required.

Answers to calculations almost always require units. Most candidates did include these, but some gave incorrect units or none at all.

Comments on specific questions

Question 1

Nearly all candidates were able to give relevant answers to each section of this question.

(a) Most answers included the idea that white blood cells help to defend the body against pathogens. The term ‘germs’ is not a suitable one to use at this level. Relatively few candidates were able to describe the action of phagocytes in engulfing bacteria (or pathogens) or lymphocytes in producing antibodies. Some thought that white blood cells help in blood clotting.

(b) A high proportion of answers began by describing how blood flows into the atria through the veins. There was much confusion about the path of blood through the heart; many candidates described the ventricles pumping blood into the atria. Another common error was to suggest that the valves pump blood. However, there were also many good answers in which candidates described the muscles in the ventricles contracting.

(c) Answers generally referred either to the presence of valves in veins and not in arteries, or the thickness of the walls of the two types of vessels. They were generally able to relate these features to the presence of blood at high pressure in the arteries. Several candidates, however, described the arteries ‘pumping’ blood, which is incorrect.

(d) Where candidates understood that transpiration is involved in the movement of water through the plant, they were generally able to give good answers, relating high temperatures to a higher transpiration rate and therefore a greater ‘suction’ force pulling water up the xylem vessels. However, there were a surprising number of answers suggesting that xylem vessels expand when it is hot, or that the plant actively transports water into its roots and up to its leaves.

Question 2

The early parts of this question were generally answered well, but the calculations proved difficult for weaker candidates.

(a) Most answers to Part **(i)** were correct. Part **(ii)** was more difficult, but many candidates were able to identify liquid A as being alkaline, and therefore providing hydroxide ions for the reaction described. For Part **(iii)**, they needed not only to identify C as being acidic, but as being 'very' acidic or 'more acidic than D'.

(b) Part **(i)** was well answered, although a few confused exothermic and endothermic. Part **(ii)** was less well done, although many correctly explained that the reaction was now complete, and that no more heat was being released. Some also suggested, correctly, that the addition of cold acid would cool the mixture.

In Part **(iii)** and **(iv)**, candidates who attempted to use molecular masses in their calculations could not provide any suitable working or answers to these questions. Many had several attempts at **Part (iii)**, before eventually settling on the simple calculation that was required. A few lost a mark for an otherwise correct calculation if they used the wrong volume of KOH in their calculation (often 15 cm^3) or did not convert to dm^3.

A number of candidates could not answer Part **(v)**, but many were able to do this correctly.

Question 3

Weaker candidates often did very poorly on this question, especially Parts **(a)** and **(b)(iii)**.

(a)(i) The expected answer was that the two processes both involve the nucleus of an atom, but relatively few candidates were able to write anything relevant.

(ii) This, too, proved very difficult. While there were some good answers, others appeared to know nothing about either nuclear fission or fusion.

(iii) Most candidates gained at least one mark here, and there were often correct descriptions of the harm that can be done to humans and other living organisms by radiation, or a description of the problem of disposing of radioactive waste. Many, however, appeared to think that radiation leaks are a normal day-to-day occurrence.

(b)(i) This was, in general, answered well. Common errors included suggesting that a high voltage reduces the resistance, or that increasing the voltage reduces the loss of 'electricity' from the cables.

(ii) This, too, was generally answered well, and most candidates were able to carry out the calculation correctly.

(iii) Almost all candidates found the task of describing how a transformer works quite a challenge. There were some good answers, but they were very few and far between. Many candidates did not know what is meant by an 'induced' current. It was common to see no mention of a.c., or of a *changing* magnetic field. Some candidates wrote about the coils 'moving', apparently confusing a transformer with a generator.

Question 4

Nearly all candidates gained a good number of marks in this question, especially in **Question (a)** and **(c)**.

(a) This was almost always answered correctly, although a few suggested 'horns' as a characteristic feature of mammals.

(b)(i) Again, this was usually answered correctly.

(ii) This question proved much more difficult than expected. Relatively few candidates recognised that the gene would be present in all cells (at least, all of those that have a nucleus). Common errors included the suggestion that the gene would be present only in gametes or in ‘horn cells’.

(c) This was not an easy question, yet it was often very well answered, even by candidates who had done poorly in other parts of the paper. Most candidates were able to explain the change in the population in terms of selection, with the genes conferring long horns not being passed on to offspring. A few, however, suggested that the sheep purposefully made their horns shorter so that they would not be shot.

(d)(i) The production of sweat in hot conditions was usually mentioned, but not all candidates appreciated that it is the *evaporation* of sweat that has the cooling effect.

(ii) This was not at all well answered. Only a very few candidates correctly explained that the arterioles delivering blood to the outer parts of the skin constrict, thus reducing blood flow near the skin surface and hence also reducing the loss of heat by radiation. Many simply stated that ‘the blood vessels get narrower’, without saying where these blood vessels are. Many described the blood vessels ‘moving deeper into the body’.

Question 5

Whilst many candidates had difficulty answering the questions about digital signals, they generally did better in the later parts of this question.

(a) Good answers to Part **(i)** generally involved the mention of signals being sent as ‘pulses’ or a series of ‘on-offs’. Part **(ii)** was less easy than Part **(i)**, but some candidates were able to describe how digital signals are less affected by ‘noise’.

(b) This was a simple recall question, and most candidates were able to identify the two gates correctly. Some, however, said that the second gate was a ‘no’ gate, rather than a ‘not’ gate. A significant number of candidates had no idea, and made up names such as ‘in’ and ‘out’.

(c)(i) Nearly all answers showed the rays coming to a focus on the principal axis, but the focal point was often incorrectly worked out.

(ii) A very large proportion of candidates could not list the three primary colours, often giving yellow instead of green.

(iii) This was usually well answered, although a few candidates thought that the speed of the waves would differ.

Question 6

Part **(a)** was very accessible, but later parts of the question were less mark yielding.

(a) Most answers included three correct answers here. The most common error was to confuse glass and ceramics, or to suggest that silicon oxide is used for making aluminium.

(b) This proved to be a discriminating question, in which good candidates often gave excellent answers while others struggled to find anything relevant to say. Many made the error of stating that silicon oxide is an ionic compound. Good answers described it as having a giant structure, with many strong bonds requiring a great deal of energy to break them.

(c)(i) The correct answer, ethane was given by most candidates.

(ii) This, like Part **(b)**, was a good discriminator. A common error was to include oxygen, O_2, in the equation. A few candidates wrote it in reverse, showing ethanol breaking down to produce ethane and water. Some wrote word equations.

(iii) This was well answered, although a few candidates stated that the bromine water would change from orange to 'clear' rather than colourless.

(iv) This, too, was generally well answered. The most common incorrect answers mentioned filtration.

Question 7

Many candidates gained full marks on this question.

(a) Both parts of (a) were generally answered correctly, as candidates recognised that B has no velocity and therefore no momentum, while C is accelerating and therefore has changing momentum. Some answers were over-elaborate, attempting to give explanations in terms of balanced or unbalanced forces.

(b) This calculation was generally correct, and most candidates gave a unit with their answer.

(c) Most candidates used the correct formula for kinetic energy. One mark was available for stating this equation, but some candidates did not do this. Candidates should be reminded that they need to write the full formula, that is ke = $^1/_2$ mv^2. Formula triangles are not sufficient. Some, having written the formula correctly, forgot to square the velocity when they carried out the calculation.

Question 8

(a) A surprising number of answers did not mention sunlight. Most, however, did describe photosynthesis and the production of glucose.

(b)(i) Many candidates did not know that biomass is the mass of living organisms, and their answers often revealed that they do not know what they are drawing when they draw a pyramid of biomass.

(ii) This was intended to be an easy question, but it proved not to be so. Only a relatively small proportion of candidates recognised that the two top boxes in the pyramid represent consumers.

(iii) Those candidates who recognised that biomass is related to energy, and that energy is lost between tropic levels, quickly gained the two marks available with a relatively short answer. Many candidates, however, did not mention energy and therefore could not provide a suitable explanation. They often tried to explain the shape of the pyramid in terms of 'need' - the boxes low down in the pyramid are large in order to feed the animals in the upper boxes.

(c) One mark was available here for simply saying that pesticides kill pests, but many answers did not mention this. Many candidates suggested that they 'keep pests away', which are not what pesticides do. The second mark was for stating that the removal of the pests would increase yield, but once again relatively few candidates included this idea in their answers.

(d) The syllabus asks candidates to discuss one problem of diet in one part of the world, but many appeared not to have thought about this and could only give very general answers about people not having enough to eat in Africa. Better answers were more specific, describing a particular dietary problem (for example not having enough protein or energy content in the diet, or eating too much fat), its consequence (for example kwashiorkor, marasmus, obesity) and how this problem might be relieved.

Question 9

This question was, on the whole, well answered.

(a)(i) This was generally answered correctly, although a few candidates gave the symbol rather than the name of potassium.

(ii) This, too, was usually answered correctly. And most candidates explained that nitrogen and phosphorus are in the same group in the periodic table, or that they both have five electrons in their outer shell. A few confused potassium and phosphorus. Some introduced 'new' elements not mentioned in the question, such as sodium.

(b)(i) Most answers correctly gave hydrogen and nitrogen.

(ii) A surprising number of candidates were not able to show the bonding diagram for ammonia correctly. They sometimes did not give the symbols for the elements at all, or wrote formulae such as N_2 in the circles. Shared pairs of electrons were often correctly shown, but the two unpaired electrons remaining in the outer shell of the nitrogen atom were frequently omitted.

(iii) Many candidates did this well, correctly working out that the ion has the formula PO_4^{3-} and explaining this in terms of the need to balance the charge on the ammonium ions, resulting in a compound with no overall charge.

(iv) This, too, was often well answered. Most candidates explained how faster moving particles would result in a faster reaction. Some of the better candidates also attempted to explain the effect that this might have regarding the reverse reaction, and if this was correctly done then credit was given for it.

Question 10

There were many very good answers to this question, and full marks were often given.

(a) Good answers described the greater kinetic energy of particles at higher temperatures, resulting in more frequent collisions with the wall of the tyre. Some answers, however, did not mention particles at all, while others simply said that there were more collisions (which is not the same as more frequent collisions), or only mentioned collisions between the particles and not between particles and the tyre wall.

(b) Most candidates recognised that this was to do with pressure, and gave good answers explaining that the large surface area reduces the pressure and hence the likelihood that the skis will sink into the snow. Some gave the formula pressure = force/area, which was credited. A common error was to say that the large surface area spreads the 'pressure' over a wider area.

(c) Once again, most candidates were able to give a suitable answer here. They nearly all recognised that the earthquake produces vibrations or waves, which can travel through the Earth to the surface.

CO-ORDINATED SCIENCES

Paper 0654/04

Coursework

(a) Nature of tasks set by Centres.

19 Centres submitted coursework for the June examination. Most have provided coursework in previous years and have acted on advice given. New Centres were well prepared and offered a safe selection of well tried practical exercises. In most Centres all the tasks set were appropriate to the requirements of the syllabus and the competence of the candidates. The standard of candidates' work was of a slightly higher standard than previous years.

(b) Teacher's application of assessment criteria.

In all 19 Centres the assessment criteria were understood and applied well for all of their activities. There has been a sustained improvement in the Centres' application of assessment criteria. Distance learning seems to act as a good preparation for coursework assessment. No Centre tried to assess both skill C1 and C4 in the same investigation.

(c) Recording of marks and teacher's annotation.

Many Centres write comprehensive summaries to support the marks given. Few indicate the point on the script at which the mark was awarded. Once again suggestions have been made encouraging the use of annotation on candidates' scripts. There is still scope for further improvement. Tick lists remain popular particularly for skill C1.

(d) 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.

CO-ORDINATED SCIENCE

Paper 0654/05

Practical

General comments

The instructions for the preparation of **Question 1** were probably more time consuming and more involved than in previous years. Difficulties have been noted and will be taken into account. There was some evidence suggesting that the prepared solutions did not meet the criteria written in the instructions. One example concerns the protein solution. The instructions clearly stated that the protein solution should be cloudy and if after preparation a clear solution remained it ought to suggest that something is not right. Answers to **Question 1** were in the main rather poor. A small number of Supervisors did not fully complete their own answers. It has been said before but perhaps needs saying again that candidates may suffer if a complete set of results is not enclosed. Answers to **Questions 2** and **3** were usually good.

Some Centres suggested that there was insufficient time for all candidates to complete the paper. Whilst this may have been true, it is the same for all and a successful examination does not necessarily require time for all to complete the paper.

Comments on specific questions

Question1

Candidates certainly found this a difficult question. The difficulties in a number of cases may have been due in part to poor preparation of solutions but certainly any such difficulty was compounded by the fact that candidates were not making sensible observations. Presumably most had never carried out an experiment similar to this and so did not understand what the experiment was about. The candidates at a few Centres did perform well and confirmed that there was nothing wrong with the exercise. Most but by no means all candidates scored the first mark for correctly completing the contents column. The remainder of part **(a)** produced all combinations of results. Expected results were: tubes 1 and 3 remained cloudy, tube 2 clear, no change in tube 4 and tubes 5 and 6 a blue/black colour. Part **(b)** was poorly answered. Few correctly recorded tubes 2 and 4 in **(i)**, often it was just tube 4 but frequently a whole collection of tubes. In **(ii)** many gave the number of a tube rather than the name pepsin and in **(iii)** the significant presence of acid was usually missed. Part **(c)** was again poorly answered. A lack of understanding of what was happening meant the questions were difficult and marks hard to come by.

Question 2

Generally well answered. A number of candidates assumed that the measurements were only required to be to the nearest centimetre. Although not penalised on this occasion it is considered bad practice to make such an assumption. The Fig. 2.1 clearly showed measurement 2 as the largest and a mark was lost if the recorded figures did not show this. A good number failed to follow the instruction to record the mass to the nearest gram and significantly some were less than 20 g! Most were able to correctly calculate the density from their own figures. The mark was not awarded if the result was greater than 3 g/cm^3. The figure for d_1 in part **(e)** should have been 10 cm less than the balance point. A number of candidates seemed to disagree with this. The value for d_2 had to be sensible and be within the range suggested by earlier figures. Values greater than the balance point were often quoted and scored no mark. The majority correctly used the equation and produced a sensible figure for the mass, going on to calculate the density. One of the two marks was awarded for a figure within 0.2 of the Supervisor's figure. Many scored both marks in **(g)** by pointing out the difficulty in accurately measuring the sides of the moulded piece of plasticine. In contrast, few could produce a sensible answer to part **(h)**. Many decided to provide a reason for what the density might be rather than describing an experiment. A large number assumed the plasticine would have melted. Although not a likely event, such a change would have been stated and not left for candidates to make a guess. The expected method was to place the plasticine in water at 80°C in a measuring cylinder to measure the displacement. Assuming no change in mass, the density could be calculated.

Question 3

The majority of candidates performed the experiment very well and collected a satisfactory volume of gas. A small number appeared unable to correctly record the mass (unless the mass provided was far removed from the instructions) and some only managed to collect less than 10 cm^3 gas. The acceptable volume needed to be within the range 40-60 cm^3. Some candidates lost marks by not naming the gas – see **(b)(i)** and **(e)(i)**. If the name is asked for, a formula will not be acceptable. In **(b)(ii)** the most common answer was oxygen and did not score the mark. Although most realised that "sucking back" meant water entering the hot tube, few appreciated the effect of cold water on a hot glass test-tube. The colour required in **(d)** was a suitable colour around blue and a pH of about 10. Most scored both marks. The same could not be said for **(e)(ii)** where a pH of 1 was common. Was the solution from **(e)(i)** used? The majority noted the bubbles in **(e)(i)** but hydrogen was often the conclusion. The expected answer in **(f)** was to use a gas syringe. Whilst many did know this, in a few Centres it appeared that the use of such a device had never been encountered.

COMBINED SCIENCE
CO-ORDINATED SCIENCES

Papers 0654/06

Alternative to Practical

General comments

As usual, this paper contains questions that encourage the candidates to imagine themselves at the laboratory work-bench, actually doing the investigations on which the questions are based. Parts of each question demand a knowledge of laboratory procedures appropriate to the syllabus. Other sections require the candidate to record their observations and to display or manipulate the data. Conclusions must be drawn from the information. Finally, the candidate may have to suggest extensions to the investigation or to use their knowledge to explain certain aspects of the experiments.

Some candidates did not read the descriptions of the experiments carefully enough and so were unable to answer the more tricky and subtle questions. Those without sufficient laboratory experience were caught out, as usual, by questions that required a certain degree of skill and experimental aptitude. However, there was a smaller proportion of weak candidates than usual. The majority of Centres are to be congratulated on their success in preparing their candidates for this paper. Many excellent candidates showed real insight and ability in their answers. Correct answers were given to every question but no one candidate scored 100%.

Comments on specific questions

Question 1

The question described the procedure for testing two digestive enzymes, amylase and pepsin, to discover whether their activities are affected by different pH levels. The pepsin was added to a cloudy protein solution with and without hydrochloric acid, and the amylase was similarly added to starch solution. Finally, all the mixtures, together with the unmixed protein and starch solutions were kept at 40° C for five minutes: the candidates were told that the acidified pepsin-protein mixture had become clear. The un-acidified amylase-starch mixture had undergone digestion; shown by the use of iodine solution.

(a) (i) Most candidates correctly listed the contents of the six test-tubes.

(ii) The observations of the protein tubes, recorded as cloudy or clear, gained two marks. A large number of candidates tried to give more information about the reactions that could not be observed.

(iii) The recording of the observations following the addition of iodine to the starch tubes gained another two marks. Candidates found this to be harder than part **(i)**, as they needed to recall that starch gives a blue-black colour with iodine.

(b) (i) The question "Which enzyme worked better in conditions of low pH?" was often incorrectly answered, because "low pH" was thought to mean "a low concentration of acid" whereas the opposite is true; so "amylase" was the wrong answer.

(ii) This followed part **(i)**, asking for an explanation for the lack of activity of amylase in the tube containing hydrochloric acid. Unfortunately the candidates answering "amylase" on part **(i)** sometimes explained that "amylase only works well in conditions of low pH", so losing this mark as well.

(iii) The reason was asked for the inclusion in the experiment of tubes containing only starch or protein. A minority of candidates used the word “control” in their answer. “To see whether starch or protein will digest in solution at 40°C without the enzymes” was accepted, but there were many poorly phrased answers, and the response "to compare with the other mixtures" was not given a mark.

(c) Finally, a test for protein in solution was sought from the candidates. The name of the test was not necessary if the candidate suggested the addition of copper sulphate and sodium hydroxide. “Benedict’s” solution was NOT accepted, even though it would work in practice, giving the same purple (mauve, violet) colour that gained the second mark.

A commendable proportion of candidates gained all or most of the marks for this question.

Question 2

This question, together with **Questions 1** and **3**, is based on the corresponding practical examination. The candidates in the practical examination had to find the density of plasticine by two different methods. In the first method, a cube of plasticine having each side about 2 centimetres was made by hand. It was measured using a ruler and then weighed on a balance. In the second method, the volume of the cube was found by displacement of water in a measuring cylinder and the mass was found using a balanced metre rule and a known mass. Most errors in this question were because the candidates did not imagine themselves actually carrying out the experiment. The importance of this ability was mentioned in the introduction.

(a) (i) Most candidates managed to find the length of one side of an illustrated cube in millimetres, convert this to centimetres and then find the cube of the number to give the volume. The cube in the diagram had rounded corners, illustrating the difficulty of making a perfect cube. Although the correct method of calculating the volume was given, some candidates substituted different numbers in the equation.

(ii) The mass was found using the diagram of the balance window, as usual. The subdivisions of the scale were 0.2 g each, some candidates read them as 0.1 g; thus, 25.1 g was correct but 25.2 was not.

(iii) Too many candidates multiplied the mass and volume to find the density, but most used the correct method here, and errors in parts **(i)** and **(ii)** were carried forward.

(b) (i) There were some candidates who did not realise that part **(b)** was concerned with an entirely different way to calculate the density of the plasticine. Thus, they tried to use data from part **(a)**. The measuring cylinder showed the total volume of water and plasticine as 110 cm^3, after 100 cm^3 was the initial volume of water. It should have been simple enough!

(ii) Now a diagram showed a symmetrical 100 cm beam with a 50 g mass at the 30 cm mark on a metre rule, balanced by the plasticine at the 90 cm mark. The first task was to find the distance of the two masses from the pivot. Some candidates measured the diagram on the page instead of calculating! Fortunately the artist had drawn it to scale, so the two distances on the diagram were in the ratio of the actual distances.

(iii) The equation for calculating the mass of plasticine was given, so it was just a matter of substituting the distances from the pivot, calculating 20 x 50 g and then dividing by 40. Alas, some candidates found the answer as 2.5 g because they calculated 20 x 50 as 100.

(iv) The density of plasticine was found using these values of the mass and volume. The same mistake was made here as in **(a)(iii)**.

(c) Candidates were invited to suggest which measurement of volume was the more accurate. There were two possible answers. The shape of the hand-made cube and the measurement of its dimensions was sure to be inaccurate. Also, the scale of the measuring cylinder showed only 10 cm^3 increments, so it was impossible to measure the volume to the nearest cm^3. Either of these observations could gain the two marks. However, many candidates failed to make sensible suggestions. A large proportion of errors arose because the question was not understood, so mass measurements were discussed. Others wrote that it was difficult to measure the cube with a ruler. This gained no marks. Comments about human error in measuring were not relevant, since this could be involved in either of the methods of finding the volume.

Most of the better candidates were able to gain 9 or 10 marks for this question.

Question 3

The decomposition of a carbonate, substance **X**, to give a measured volume of carbon dioxide, forms the basis of this question.

(a) **(i)** and **(ii)** The procedure for heating the carbonate and collecting the evolved gas, in a measuring cylinder over water, is outlined. The candidate had to suggest what happens if the delivery tube is not removed after heating, from below the surface of the water in the trough. This question was found to be the hardest part of the examination. Many candidates suggested that the gas in the measuring cylinder returned to the test-tube in which substance X was heated. A very few correctly said that water entered the test-tube, but were usually unable to give the reason for this, that the gas in the test-tube cooled down and contracted so that air pressure forced water into the tube to take its place. This kind of investigation, in which a gas is collected over water from a heated source, clearly does not form part of the laboratory experience of most candidates; this is a great pity.

(b) Surprisingly, many candidates could not read the volume of gas in the inverted measuring cylinder.

(c) **(i)** The question said "Explain how the candidates can use limewater to test the gas that is in the measuring cylinder". This should have been clear enough, but most candidates did not absorb the literal meaning of the question. The gas is in the cylinder over water. How do you do the experiment? The Examiners looked for suggestions that the measuring cylinder must be covered and lifted out of the water, limewater is poured in and then the cylinder is shaken, or the gas in the cylinder is sampled and passed into limewater. Answers such as "Bubble the gas through limewater" or "add limewater to the water in the trough" gained no marks. Such answers show that candidates had not imagined themselves to be actually doing the experiment, a requirement noted in the introduction to this report.

(ii) Most candidates could state that the gas was carbon dioxide.

(d) **(i)** and **(ii)** Substance **X**, and the residue from heating it, are tested with Universal Indicator. The pH of the solutions is said to be 8 and 10 respectively. Candidates were not expected to know the accurate colours of the indicator at these pH levels. However, a change of colour from greenish-blue to blue-purple was looked for. For example, the colours blue and purple were accepted as the correct answers.

(e) Candidates were asked to suggest an alternative method for collecting the gas carbon dioxide that does not use water, such as the use of a graduated syringe. Many could not do this, suggesting that candidates had never seen this happen. A few enterprising candidates suggested that carbon dioxide could be collected over oil, and credit was given for this answer. Some diagrams showed apparatus that would have exploded when heated.

Question 3 was the least satisfactorily answered of all the questions in the examination. The Examiners have commented in previous years on the poor performance of some candidates in questions based on chemistry. There is still room for improvement in this respect.

Question 4

This question is based on an experiment to investigate the process of transpiration in leaves. Success in answering the question is built on a proper understanding of the procedure. Four sets of leaves are compared, three of which are treated with grease on one or both surfaces. The leaves are weighed before and after a 48-hour period.

(a) Almost all candidates were able to find the change in the masses of the leaves before and after the 48 hours drying period.

(b) (i) Most candidates were successful in calculating the average loss in mass of each set of leaves. The final set lost an average of 0.03 g: a few candidates did not calculate to this accuracy and lost a mark. A number of candidates divided by 2 to find the average of three amounts, showing a mathematical weakness.

(ii) It was easy to see that greased leaves lost far less mass on average than ungreased ones, an answer given by most candidates.

(iii) The question "Which surface, upper or lower, allowed the greater amount of water loss?" proved more difficult. Some confused candidates thought that the question referred to the surface that had been greased. Their incorrect answer could not be supported by the data, so they lost two marks.

(iv) The lower surface of the leaves allowed more loss in mass. Candidates were expected to refer to the greater concentration of stomata on the lower surface, but if they adequately described the waxy layer on the upper surface of some leaves, a mark was awarded.

There were many completely correct answers to this question.

Question 5

In the experiment on which this question is based, 10 cm^3 portions of water at 80°C were added to 50 g of ice and the resulting temperature of the mixture was measured each time. No temperature rise was noted until the 6^{th} and subsequent additions. Three thermometer scales were shown so that the candidates could read and record the last three temperatures.

(a) The thermometer readings were expected to be recorded to the nearest 0.1°C, appropriate to the details of the thermometer scales. Alas, many candidates failed to record 20.0°C for the third reading and so lost a mark.

(b) The candidates had to plot volume added against the temperature of the mixture. A graph grid was supplied with the x- and y-axes marked and labelled. The y-axis began at -10°C, a fact that misled some candidates, since they plotted the 0°C reading on the lowest line of the graph. Only one mark was deducted for this error, but the candidates inevitably penalised themselves further in part **(c)(ii)**. The correct graph had the shape of two straight lines intersecting at 51 cm^3 and 0°C, the point at which all the ice had melted and the temperature of the mixture began to rise.

(c) (i) Candidates had now to explain why the temperature did not rise until six portions of hot water had been added. A distractor to the correct answer was provided by the equivalence of the masses of ice and hot water! The answer "because 50 g of hot water had to be added to 50 g of ice" was not accepted. Other candidates said that the ice did not begin to melt until this point, or that it took a long time to melt. The answer that there was still some ice present in the mixture until a certain volume of hot water had been added, or that all the heat energy added had been used in melting the ice while the temperature did not rise, was acceptable.

(ii) Candidates who had correctly plotted and drawn the graph, were able to deduce the volume of hot water needed, about 51 cm^3.

(d) An equation was given for the calculation of the amount of heat energy needed to melt the ice. Candidates had merely to substitute the temperature of the hot water and the volume deduced in **(c)(ii)** and then complete the calculation. The most common error here was in giving the wrong temperature of the hot water, information that was right at the beginning of the question. Correct calculation was credited, for one mark, even if substitution of one value was incorrect.

Some candidates gained full marks on this question, but overall the answers were slightly disappointing.

Question 6

The solubility of oxygen in water is of vital importance to the planet and all its inhabitants. An experiment to discover the composition of dissolved air is described in this question. Water from a mountain stream is boiled and the boiled-out air is collected. Then its composition is investigated by using up the oxygen in rusting iron.

(a) The graduated tube in which the volume of boiled-out air is to be found is placed over the end of the delivery tube; what must it contain? Experience of collecting any gas over water gives the clue, but a significant number of candidates did not answer "water".

(b) "What happens to the steam produced when the water boils?" An innocent enough question, but the majority of candidates seemed to fall into the trap and say that it was collected in the graduated tube. Some candidates said that the steam evaporated and became a gas, and there were even a few who said that it became hydrogen!

(c) The section of the graduated tube showing the water level was illustrated here. Alas, some candidates did not realise that the whole of the tube was not shown, so they did not record the actual reading but tried to calculate the volume by subtraction. Also, the subdivisions of the scale were 0.2 cm^3 so others recorded 12.2 when it was actually 12.3.

(d) After iron filings had been allowed to rust in the air within the tube, its volume had decreased. The scale was again shown. An error in finding the volume, similar to that in part **(c)**, was made by some candidates.

(e) (i) The volume of oxygen removed could be found by subtraction. Errors were "carried forward" when this was marked.

(ii) The percentage of oxygen in the boiled-out air could now be found. Some candidates, having answered correctly to this point, failed to find the right formula for this calculation. The data leads to a composition of about 35% oxygen by volume in the boiled-out sample. Errors were carried forward when marking.

(f) (i) Given the normal composition of air, candidates were asked to suggest which is more soluble in water, oxygen or nitrogen. The greater proportion of oxygen in boiled-out air should have led them to the conclusion that oxygen is rather more soluble.

(ii) Asked why the solubility of oxygen in water is important to aquatic plants and animals, candidates showed some ignorance about processes in which oxygen is used up. Many candidates said that oxygen is used in photosynthesis. Any reference to respiration gained the mark. Such comments as "they will die without oxygen" gained no credit.

This question was effective in demonstrating the insight of the better candidates and the lack of laboratory experience of others.