BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1995

SCIENCE

3/4 UNIT

PAPER 2—ELECTIVES

3 UNIT CANDIDATES: Time allowed—One hour and a half
4 UNIT CANDIDATES: Time allowed—Three hours
(Plus 5 minutes' reading time)

DIRECTIONS TO CANDIDATES

3 Unit Candidates

- Attempt TWO questions. These questions may be chosen from ANY Group.

4 Unit Candidates

- Attempt FOUR questions. These questions MUST be chosen from AT LEAST THREE Groups.

All Candidates

- Each question is worth 25 marks.
- Answer each question in a *separate* Elective Answer Book.
- Write your Student Number and Centre Number on the cover of each Elective Answer Book.
- Write the Course, Elective Name, and the Question Number on the cover of each Elective Answer Book.
- You may ask for extra Elective Answer Books if you need them.
- A Periodic Table and Data Sheet are provided as a tear-out sheet at the back of this paper.

CONTENTS

Marks

GROUP 1—BIOLOGY ELECTIVES

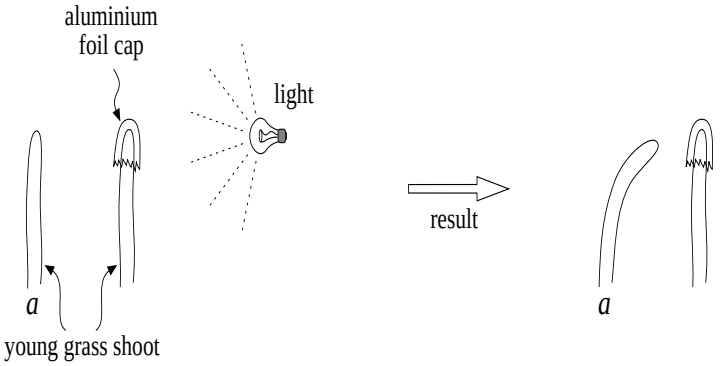
Marks

QUESTION 1. Flowering Plants and Mammals

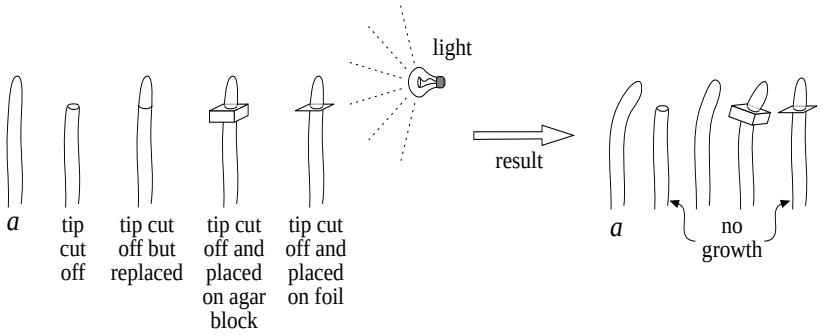
(a) A botanist carried out an experiment in which the roots of a whole tree were placed in a solution of picric acid, a metabolic poison. For several days the botanist measured the rate of transpiration, which did not decline. Explain these results. **2**

(b) The diagram shows three experiments carried out on growing grass shoots. **5**

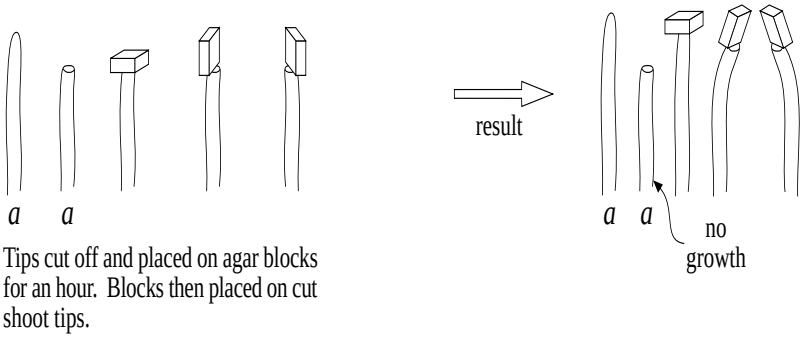
Experiment I



Experiment II



Experiment III



(i) What conclusions would you draw from each of the experiments?

(ii) In each of these experiments, what is the significance of the shoots marked *a*?

Question 1 continues on page 4

QUESTION 1. (Continued)

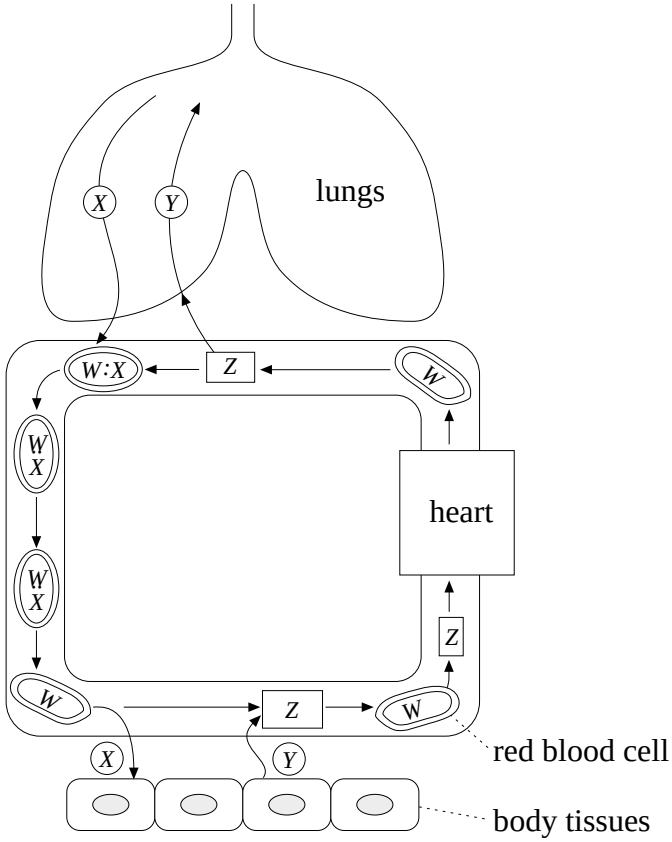
Marks

(c) In the sensitive plant *Mimosa pudica*, the leaves fold up immediately the plant is touched. Is this response hormone-linked? Explain your answer. **2**

(d) (i) What are the products of the digestion of fats? **2**

(ii) How are these compounds transported to other tissues in the body?

(e) The diagram shows the relationship between the lungs, circulatory system, and body tissues. **4**



(i) Identify:

1. *X*

2. *Y*.

(ii) In the schematic diagram of the circulatory system, identify the chemicals:

1. *Z*

2. *W*.

(iii) Why is it necessary for *Y* to be removed from the tissues?

(iv) By what process does *Y* move from the tissues to the bloodstream?

QUESTION 1. (Continued)

Marks

(f) Draw a fully labelled diagram to show the pathway of a nervous impulse in a reflex arc. Identify the receptor and the effector. **3**

(g) In flowering plants, what are the features of the cells that transport: **4**

(i) water and nutrients?

(ii) sugar solutions?

(h) Most of the native plants in Australia are unique to this continent. Nevertheless, many of the plants grown in gardens are native to very different environments elsewhere in the world. **3**

Discuss how it is possible to grow plants successfully in gardens outside their natural ecological and geographical range. Your answer should refer to the factors that affect plant growth.

QUESTION 2. Reproduction and Genetics

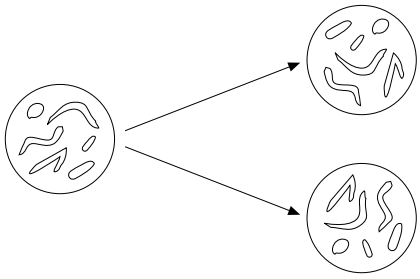
Marks

(a) (i) State ONE method of asexual reproduction. Give an example of an organism that reproduces by this method. **2**

(ii) Is genetic variation possible in an asexually reproducing organism? Explain your answer.

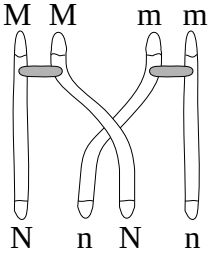
(b) Many species are able to reproduce either sexually or asexually. In a stable and favourable environment, reproduction is generally asexual. If the environment changes or becomes unfavourable, some of these organisms begin to reproduce sexually. Explain the *evolutionary significance* of this change from asexual to sexual reproduction. **2**

(c) (i) The diagram shows chromosomes in the nucleus of a cell before and after cell division by mitosis. **6**



Give TWO pieces of evidence from the diagram which indicate that mitosis has occurred.

(ii) The diagram shows chromosomes during cell division. The genotype is MmNn.



1. What type of cell division is taking place? Explain your answer.

2. In your Answer Book, draw and give the genotypes of the chromosomes in each new cell produced at the end of this cell division.

3. Are the genes M and N linked genes? Explain your answer.

QUESTION 2. (Continued)

Marks

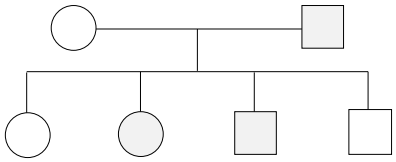
(d) State ONE way in which bacterial reproduction is: **2**

(i) *similar* to plant and animal reproduction;

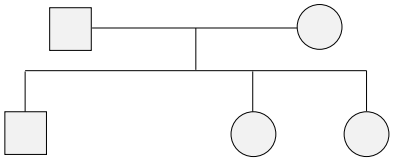
(ii) *different* from plant and animal reproduction.

(e) The diagram shows four family trees. These represent possible pedigrees to illustrate the inheritance of the condition cystic fibrosis. **2**

(A)



(B)



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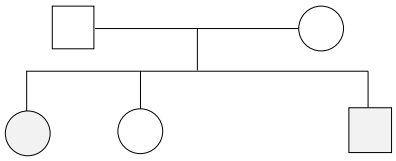
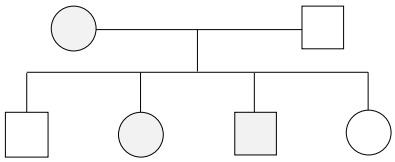


(D)



KEY

normal male

normal female

male with cystic fibrosis

female with cystic fibrosis

Which of the pedigrees A, B, C, or D shows that cystic fibrosis is a recessive characteristic? Explain your answer.

(f) (i) How is a human male genetically different from a human female? **2**

(ii) How does this genetic difference explain the fact that approximately equal numbers of human males and human females are born?

(g) Describe how the structure of DNA determines the genetic code on messenger RNA. Use labelled diagram(s) in your answer. **3**

Question 2 continues on page 8

QUESTION 2. (Continued)

Marks

(h) TWO techniques used in genetic engineering are: **2**

(i) the use of recombinant DNA;

(ii) cloning.

Briefly discuss each technique.

(i) In guinea-pigs, black coat colour (B) is the dominant trait and albinism (b) is recessive. A breeder crossed a black guinea-pig with an albino. The cross produced 10 black offspring. **4**

When the same albino guinea-pig was crossed with a different black guinea-pig, 6 black and 4 albino offspring were produced.

What is the best explanation for the results of these crosses?

In your answer, show genotypes and phenotypes (where relevant) for the parents, gametes, and offspring.

QUESTION 3. Micro-organisms and Disease

Marks

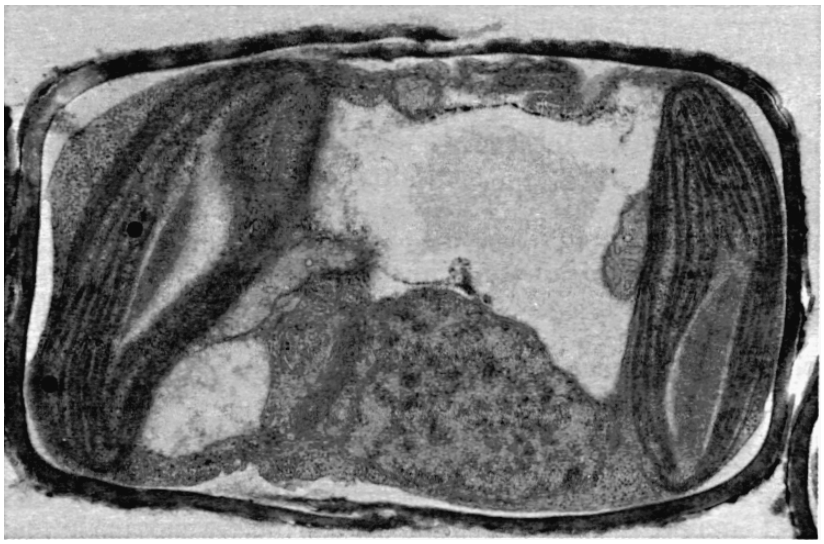
(a) An orchardist is unable to sell his pear crop because the fruit has large brown rotten spots. He wishes to prevent further losses and employs a microbiologist to determine the cause of the problem. She finds that all the rotten spots are associated with a particular fungus. **5**

Outline the techniques in sequence that she would undertake to demonstrate that the fungus is the cause of the rotten spots.

(b) (i) What is the *relationship* between antigens and antibodies? **3**

(ii) What role does this relationship play in defence against disease?

(c) The photograph is an electron micrograph of a whole cell. **3**



Dr M Vesk, EM Unit, University of Sydney.

(i) Is the cell procaryotic or eucaryotic?

(ii) What features of the cell support your answer?

(d) (i) What evidence can be provided *for* and *against* viruses being living things? **4**

(ii) Why is it difficult to treat viral diseases once they have been contracted?

(e) (i) Name a human disease caused by a bacterium. **3**

(ii) How is the disease transmitted?

(iii) What measures can be taken to prevent the spread of the disease?

Question 3 continues on page 10

QUESTION 3. (Continued)

Marks

(f) Discuss an example of: **4**

(i) a micro-organism that is of positive economic benefit;

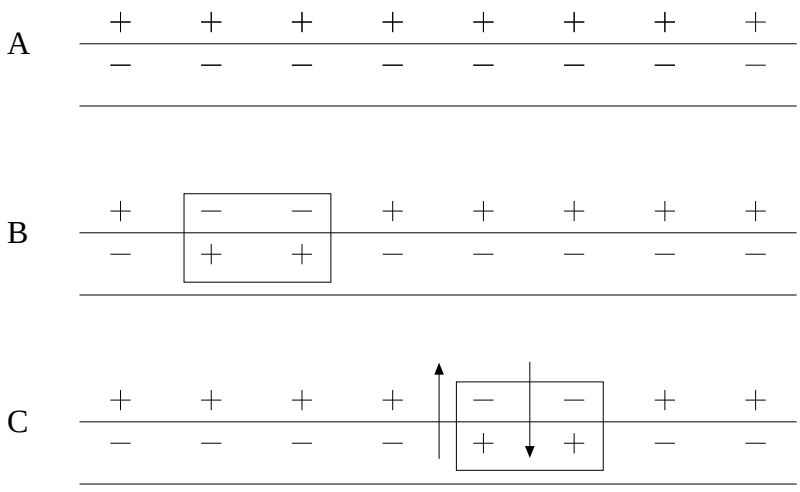
(ii) a micro-organism that is a cause of economic loss.

(g) A number of diseases of farm animals that are prevalent in other countries (e.g. foot-and-mouth disease) are absent from Australia. Explain THREE measures that can be taken to prevent the establishment of such diseases in Australia. **3**

QUESTION 4. Coordination and Control

Marks

(a) (i) The unlabelled diagrams represent the transmission of a nerve impulse. **5**



Write THREE statements (one for each of A, B, and C) that would describe what these diagrams illustrate.

(ii) Identify ONE characteristic of neurones. State how that characteristic makes neurones suitable for the transmission of messages from one part of the body to another.

(iii) Describe how the transmission of a nerve impulse from one neurone to another differs from transmission along a neurone.

(b) (i) The nervous system in mammals can be classified into two parts, the central nervous system and the peripheral nervous system. Discuss how these two nervous systems differ in structure and function. **4**

(ii) The autonomic nervous system in mammals is more concerned with homeostasis than is the central nervous system. Explain this observation.

(c) State TWO functions of the pituitary gland. In your answer, name TWO hormones secreted by the pituitary gland and the targets on which they act. **2**

(d) The nervous system and the endocrine system are both responsible for the coordination of the body. State similarities and differences that exist in their modes of action. **3**

(e) Describe ONE example of an interaction between the nervous and endocrine systems in an animal. **2**

Question 4 continues on page 12

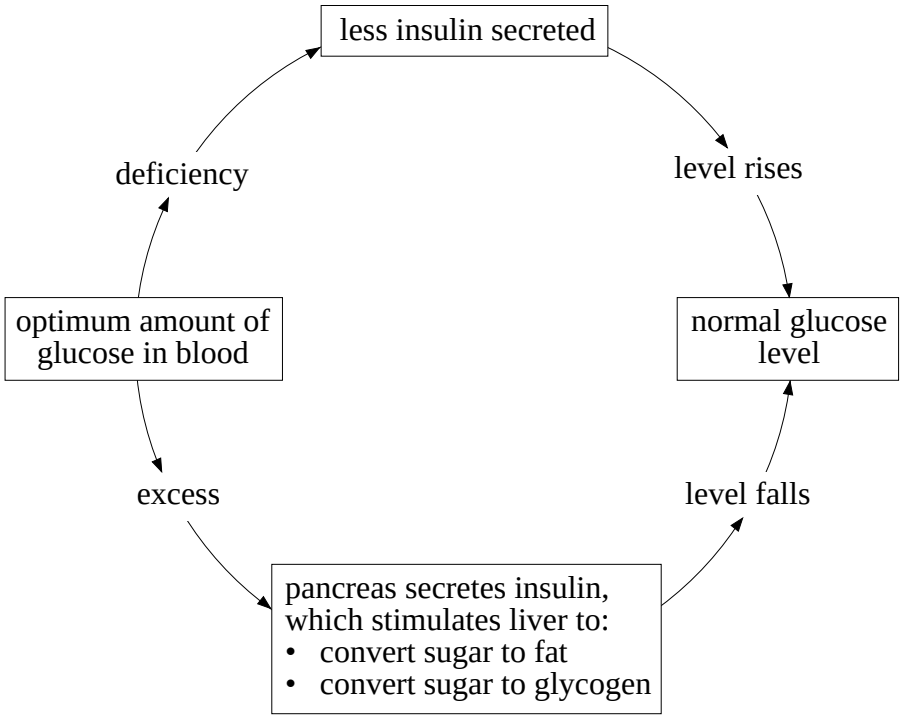
QUESTION 4. (Continued)

Marks

(f) (i) Name ONE hormone that produces a short-term effect in a mammal. **2**

(ii) Explain how this effect benefits the mammal.

(g) The flow diagram illustrates a model for the control of the glucose (blood sugar) level in the blood. **3**



(i) Define the term ‘homeostasis’.

(ii) Use the information in the diagram to explain how homeostasis is achieved.

(h) Plants are capable of producing short-term responses to environmental stimuli. Give ONE example of a short-term response. Discuss the biological significance of this response. **2**

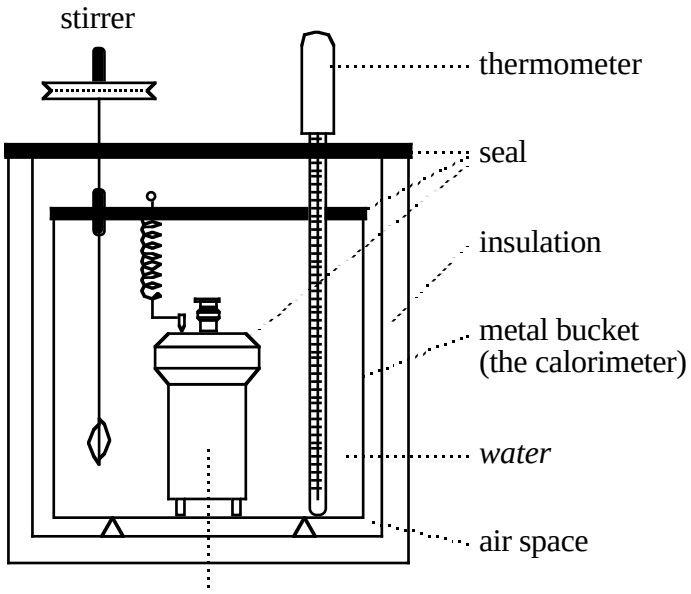
(i) Gibberellic acids and cytokinins have important roles in the coordination and control of plants. State a specific role for each hormone. **2**

GROUP 2—CHEMISTRY ELECTIVES

Marks

QUESTION 5. Energy

(a) To determine the molar heat of combustion of ethene (or ethylene), C_2H_4, a student carried out a reaction using the apparatus shown in the diagram. **3**



From 'Fundamentals of Chemistry', 4th ed., Brescia et al,
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It was assumed that the specific heat of water was 4180 J kg^{-1} K^{-1}.

Result:

- initial temperature = 22·0°C
- final temperature = 55·4°C
- mass of water in apparatus = 500·00 g
- mass of ethene (ethylene) burnt = 1·40 g

(i) Determine the molar heat of combustion of ethene in kJ mol^{-1}.

(ii) Predict whether this experimental result would be greater or less than the accepted value. Explain your answer.

Question 5 continues on page 14

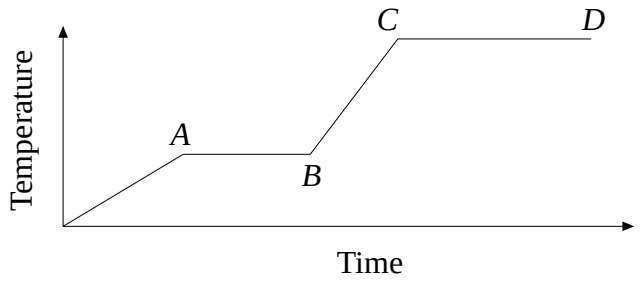
QUESTION 5. (Continued)

Marks

(b) Calculate the heat of combustion of ethyne (acetylene), C_2H_2, from the bond enthalpies given. **3**

Bond	*Enthalpy* (kJ mol^{-1} at 25°C)
C — H	414
O — H	463
O ═ O	498
C ═ O	804
C ≡ C	839

(c) A sample of H_2O is gently heated and the temperature recorded over time. The diagram shows the change in temperature with time. **3**



Explain what is happening to the H_2O in the parts of the diagram labelled:

(i) *A*–*B*;

(ii) *B*–*C*;

(iii) *C*–*D*.

QUESTION 5. (Continued)

Marks

(d) Water and solid calcium react to produce solid calcium hydroxide and hydrogen gas. **3**

(i) Write a balanced equation for the reaction (including physical states).

(ii) Calculate the heat of reaction given the following data.

Substance	ΔH_f (kJ mol^{-1})
$H_2O(l)$	–286
$Ca(OH)_2(s)$	–986

(e) Coal is used to generate electricity in Australia. However, the processes are less than 100% efficient and pollutants are formed. **4**

(i) State ONE energy transformation involved in the combustion of coal.

(ii) Name ONE pollutant formed in the combustion of coal.

(iii) Alternatives to coal as an energy source are being sought. Name ONE alternative energy source.

(iv) For the alternative energy source, state ONE advantage and ONE disadvantage in its use.

(f) Electricity can be obtained from electrochemical cells such as a nickel–cadmium battery. **5**

The overall equation for the reaction in the battery is

$$Cd(s) + NiO_2(s) + 2H_2O(l) \rightarrow Cd(OH)_2(s) + Ni(OH)_2(s)$$

and one of the half-equations is

$$2e^- + NiO_2(s) + 2H_2O(l) \rightarrow Ni(OH)_2 + 2OH^-(aq)$$

(i) Write the other half-equation.

(ii) Which electrode does the cadmium electrode represent?

(iii) Would a suitable electrolyte for this battery be alkaline or acidic? Explain your answer.

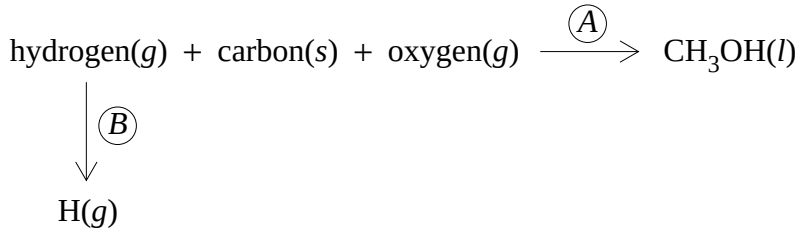
(iv) What would be the minimum voltage needed to recharge this battery? Explain your answer.

Question 5 continues on page 16

QUESTION 5. (Continued)

Marks

(g) Use the flowchart and data related to methanol, CH_3OH, to answer the questions. **4**



Melting-point	–97·7°C
Boiling-point	64·7°C
Ignition temperature	446°C
Flashpoint*	12°C

* The flashpoint of the substance is the temperature at which it catches on fire in air in the presence of an open flame.

(i) Name the enthalpy change in:

1. Ⓐ

2. Ⓑ.

(ii) At what temperature will methanol combust in air in the absence of a flame?

(iii) For safe storage and handling of methanol, which temperature from the data is considered most important?

(iv) State ONE safety precaution needed when handling methanol.

QUESTION 6. Atomic Structure and the Periodic Table

Marks

(a) William Crookes, in 1861, used selenium-containing organic compounds and their ores in spectroscopy experiments. He discovered a beautiful green line in their spectra that fitted no known element. He named this new element thallium (from a Greek work meaning 'green twig'). **5**

ISAAC ASIMOV

(i) Explain how the spectral line was produced.

(ii) What was the basis for Crookes's stating that it was definitely a new element?

(iii) Crookes did many experiments with tubes containing gases at low pressure. The tubes were connected to a high-voltage supply. The results from these experiments were that:

- radiation from the cathode travelled in straight lines;
- radiation could move a small wheel;
- the radiation was deflected by magnetic fields.

Explain each of these observations.

(b) Consider the electronic configuration of the atom of chlorine. **7**

(i) Draw the pictorial representation for the electronic configuration in the shells.

(ii) Give the symbolic electronic configuration of chlorine in terms of the subshells.

(iii) In what way is the electronic configuration of the chloride ion different from that of the chlorine atom?

(iv) Explain the similarity in behaviour of chlorine and hydrogen.

(v) Hydrogen is not usually placed in the same group as chlorine in the periodic table. Give TWO reasons for this.

(vi) How does the chemical behaviour of chlorine differ from that of potassium?

(c) It is reported that 'Davy, in October 1807, passed a current through molten potash and liberated potassium. The little globules of shining metal tore the water molecule apart as it eagerly recombined with oxygen and the liberated hydrogen burst into lavender flame. Davy danced about in a delirium of joy.' **3**

ISAAC ASIMOV

(i) Explain why potassium is not found as an element in nature.

(ii) State a chemical property of elements in Group I.

(iii) Explain why the behaviour of potassium is different from that of rubidium.

Question 6 continues on page 18

QUESTION 6. (Continued)

Marks

(d) Mendeleev's periodic table is based on the properties of the elements. **1**

Mendeleev's sequence of elements is very similar to that of the modern periodic table, which is based on energy levels. Why is this?

(e) Information is provided on three elements, *J*, *Q*, and *Z*. **4**

Element	*Electronic configuration*
J	$1s^2\ 2s^2\ 2p^3$
Q	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$
Z	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6\ 4d^{10}\ 4f^4\ 5s^2\ 5p^6\ 6s^2$

(i) Construct a table to record the following information about the three elements.

1. Total number of electrons.
2. Block position in the periodic table.
3. Name of the element.

(ii) For the element *J* :

1. name a physical property;
2. describe how that property varies down the group to which *J* belongs.

(f) Several scientists made significant contributions to our understanding of the atomic model. **5**

(i) How did Bohr explain the spectral lines of hydrogen?

(ii) Bohr's model of the atom was insufficient to explain the fine detail of spectral lines. Explain why Bohr's model was not suitable for atoms other than hydrogen?

(iii) What was Schrödinger's contribution to our understanding of the atomic model?

(iv) State the Pauli exclusion principle.

QUESTION 7. Carbon Chemistry

Marks

(a) The table shows some properties of compounds. **4**

Name of compound	*Structural formula*	*Molar mass* ($g\ mol^{-1}$)	*Boiling point* (°C)	*Water solubility*
benzene		78	80·0	low
propane	$CH_3CH_2CH_3$	44	−42·1	low
1,2-ethanediol	$HOCH_2CH_2OH$	62	198·0	high

(i) Explain how the structures of these three compounds give rise to the differences in boiling point and water solubility.

(ii) State ONE industrial *or* domestic use for *each* of these compounds.

(b) For each of the following pairs of compounds, answer the questions below. **5**

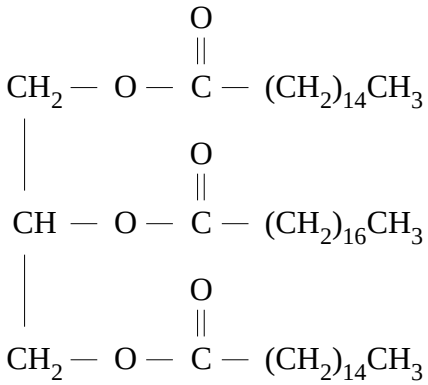
- acetylene (ethyne) and ethane
- 1-propanol and 2-propanol

(i) Give a chemical test that would enable you to distinguish between the compounds in each pair.

(ii) Write balanced equations for all reactions. Use structural formulae in your equations.

(c) (i) Describe briefly the reaction referred to as saponification of a fat. **3**

(ii) A fat, glyceryl dipalmitostearate, has the following formula.



Write the formulae for the products of the saponification of this fat.

Question 7 continues on page 20

QUESTION 7. (Continued)

Marks

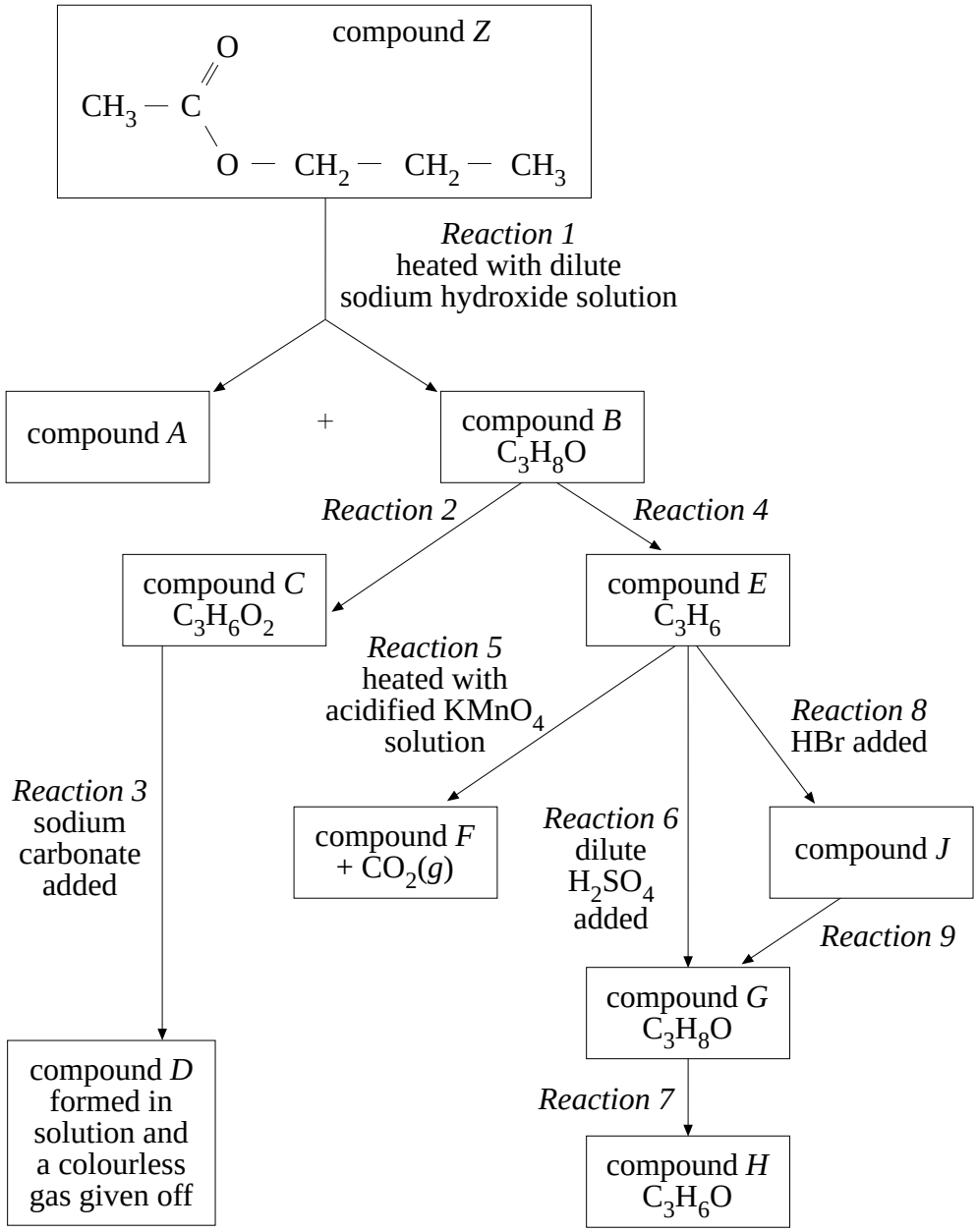
(d) The ester, ethyl butanoate, has the odour of pineapples. **3**

(i) Name the reagents required to prepare this ester.

(ii) State any special conditions necessary to prepare this ester.

(iii) Write the balanced equation for this reaction.

(e) Consider the flowchart of chemical reactions given below. **10**



QUESTION 7. (Continued)

Marks

Use the flowchart to answer the following questions.

(i) Name compound *Z*.

(ii) Write the structural formula for each of the following compounds.

1. *C*
2. *D*
3. *G* (which has a different structure from *B*)
4. *H*

(iii) Name a suitable reagent that could be used for:

1. reaction 2;
2. reaction 4.

(iv) Write the balanced equation for:

1. reaction 1;
2. reaction 3;
3. reaction 8.

(v) Name compound *J*.

(vi) Identify:

1. the substitution reaction;
2. the dehydration reaction.

GROUP 3—GEOLOGY ELECTIVES

Marks

QUESTION 8. Regional Geology

In this elective you have studied ONE of the following regions.

- North-Western Fold Belt.
- Central and Southern Fold Belt (northern areas).
- Central and Southern Fold Belt (southern areas).
- New England Fold Belt.
- Sydney Basin.
- Clarence–Moreton Basin.
- Great Australian Basin.
- Murray Basin.

(a) (i) Name the region you have studied for this elective. **5**

(ii) Describe TWO sources of information and THREE methods you used in your study of this region. Discuss the way in which *each* method or source of information contributed to your knowledge of the region.

(b) Rock units are given formal names consisting of a place name and a rock type, e.g. Gordon (place) Limestone (rock type). **6**

(i) Name a significant rock unit that occurs in the region you have studied.

(ii) State the geological period in which this rock unit formed.

(iii) Describe the characteristics you would observe in a hand specimen of a predominant rock type of this unit (colour, grain size, mineral composition, etc.).

(iv) Describe this rock’s origin and mode of formation.

QUESTION 8. (Continued)

Marks

(c) (i) Name ONE geological region that has a boundary with the region you have studied. **7**

(ii) What type of geological structure occurs at the boundary between the two regions?

(iii) Which of these two regions contains the oldest rocks?

(iv) What is the age of the oldest rocks in the region you have studied?

(v) How old are the youngest marine rocks in the region you have studied? If the region you have studied contains no marine rocks, how old are the youngest volcanic rocks in your region?

(vi) Name ONE type of fossil found in your region.

In what type of environment did this organism live?

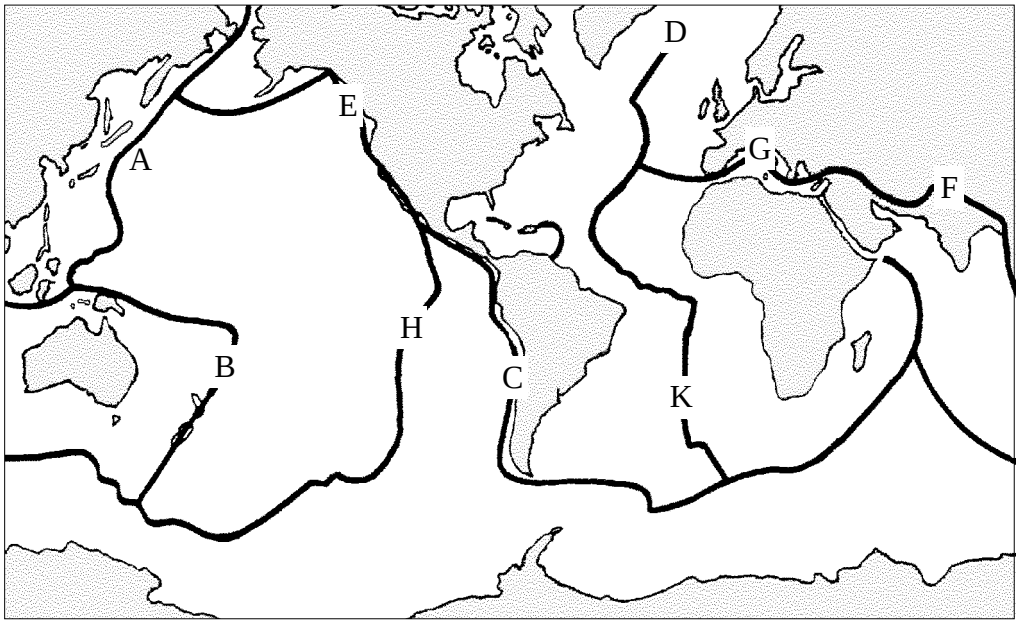
(d) Describe the present geomorphology of the region you have studied. Discuss how the present geomorphology is related to the geology (e.g. structure and lithology) of the region. **4**

(e) Name and describe the geology of a feature of special geological interest in the region. **3**

QUESTION 9. Mountains

Marks

(a) **14**



There are basically two mountain types produced by interactions at plate margins. Select TWO examples of contrasting mountains or mountain ranges that are formed by different types of plate interactions.

For *each* example, answer the following questions.

(i) Name the mountain or mountain range.

(ii) Name the type of plate interaction.

(iii) Choose ONE letter from the map that identifies a site of the plate interaction.

(iv) Discuss the formation and composition of the mountains or mountain ranges. Refer to the origin of the materials forming the mountains, and the changes that they undergo during the mountain-building process. Use diagrams to illustrate the plate interactions.

(b) The eruptions of Mount Vulcan and Mount Tavurvur in 1994 caused the evacuation of Rabaul, Papua New Guinea, and devastation of the whole area. **6**

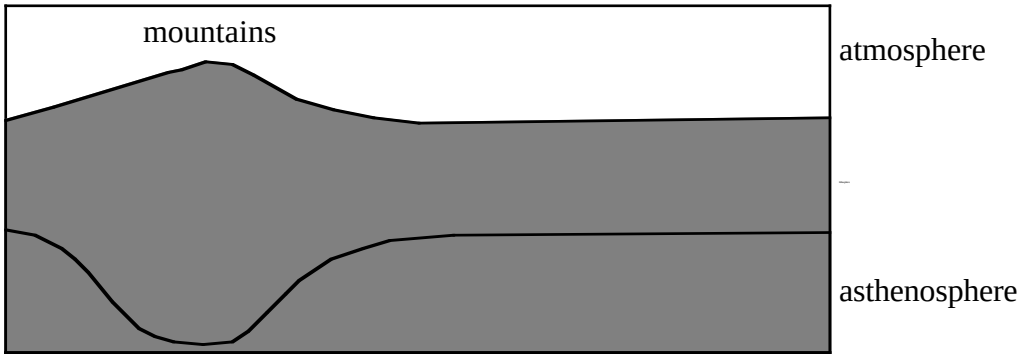
Discuss, with examples, the social consequences of volcanic eruptions in both the twentieth century and in the time of early civilizations.

QUESTION 9. (Continued)

Marks

(c) The diagram below shows the gross structure of part of a continent at some time in the geological past. **5**

NOT TO SCALE



(i) Describe the effect that long periods of erosion have on mountain ranges. Your answer should include TWO fully labelled diagrams.

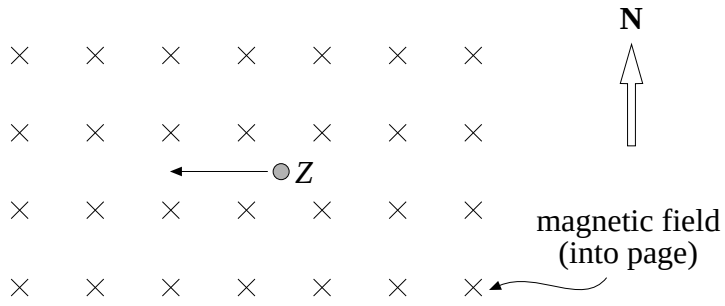
(ii) What name is given to the structure that remains after long periods of erosion?

(iii) What is the composition of this structure?

GROUP 4 —PHYSICS ELECTIVES

Marks

QUESTION 10. Electromagnetism

(a) 

3

Ignore gravitational effects in this question.

The diagram shows a particle of charge $+1{\cdot}0 \times 10^{-15}$C travelling through a region of space where there is a magnetic field. At a particular instant, the particle is at a point *Z* travelling towards the west at 1·0 km s^{-1}.

(i) Indicate the direction of the force on the particle due to the magnetic field at the instant the particle is at *Z*.

(ii) Calculate the magnitude of the magnetic force acting on the particle at *Z*, given that the magnetic flux density *B* is 0·10 T.

(b) A compass needle is placed due west of a vertical wire. A current flows through the wire. **3**

(i) What is the direction of the current if the compass needle turns to point south?

(ii) How did you determine the direction of the current in the wire?

(c) Overhead wires carrying a current have an associated magnetic field. This can affect the operation of instruments such as wrist-watches. **2**

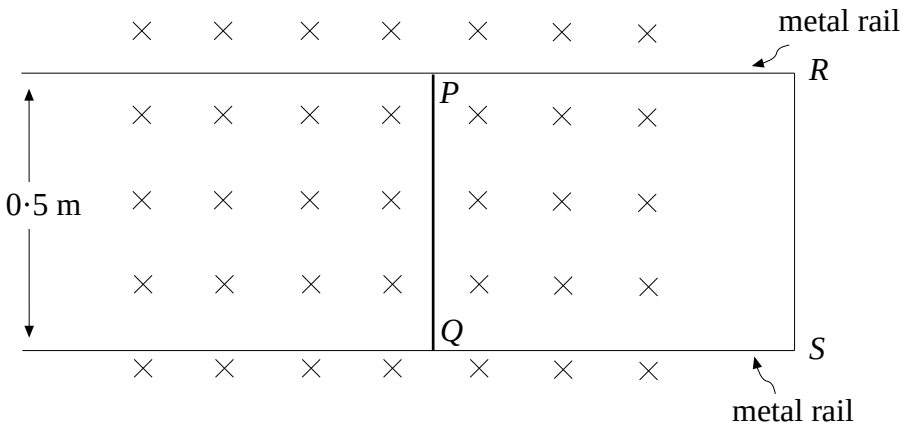
Kim's wrist-watch remains unaffected by any magnetic field with a flux density less than 0·9 T. Kim wears her wrist-watch and walks under an overhead wire carrying a current of 500 A. Is the watch likely to be affected? Explain your answer.

(d) A coil with cross-sectional area 10 cm^2 consists of 400 turns. The coil has a resistance of 1 Ω. It is mounted in a uniform magnetic field of flux density 0·01 T, so that flux passes at right angles through the coil. The coil is removed uniformly and completely from the field in 0·01 seconds. Calculate the current induced in it. **3**

QUESTION 10. (Continued)

Marks

(e) A conducting rod *PQ* makes contact with metal rails that are 0·5 m apart in a uniform magnetic field of flux density 1·0 T. The rails are joined at one end by a wire *RS*. The magnetic field is perpendicular to and into the plane of the paper as shown. The only resistance in the circuit *PQSR* is 4 Ω in the wire *RS*. **6**



The rod *PQ* is moving to the left at a constant velocity of 8·0 m s^{-1} due to an applied force F_a.

(i) What is the e.m.f. induced between the ends of *PQ* ?

(ii) In which direction does the induced current flow in *RS* ?

(iii) What is the current in *RS* ?

(iv) Calculate the magnitude and direction of the magnetic force acting on *PQ*.

(v) What is the net force acting on PQ?

(f) Two parallel wires, each 1·0 m long, carry currents of 1·0 A in opposite directions. The wires are 0·2 m apart. **5**

(i) Calculate the force between the wires.

(ii) What will happen to this force if:

1. the currents are in the same direction?

2. the wires are 0·4 m apart?

3. the wires are placed at right angles to each other?

4. the common length is increased to 1·5 m?

Question 10 continues on page 28

QUESTION 10. (Continued)

Marks

(g) A square coil of 50 turns and area 4×10^{-4} m^2 carries a current of 0·3 A. **2**

It is placed in a magnetic field of flux density 4 T.

(i) What is the *maximum* torque of the coil?

(ii) What is the *minimum* torque of the coil?

(h) Write a definition of the 'ampere'. **1**

QUESTION 11. Oscillations and Waves

Marks

(a) (i) The Earth, assumed spherical, revolves with a period of 24 hours. **4**

Calculate:

1. its angular velocity (in rad s^{-1});

2. the linear speed at the equator (in m s^{-1});

3. the centripetal acceleration of a point on the equator (in m s^{-2}).

(ii) With respect to the surface of the Earth, what is the direction of the centripetal acceleration at the equator?

(b) (i) A radio station broadcasts at a frequency of 600 kHz. What is the wavelength of the electromagnetic wave broadcast by its radio transmitter? **2**

(ii) A radio listener cannot see the radio transmitter because it is blocked by a large building. The listener can still receive the radio signal. Explain why this is possible.

HINT. The centre of the visible light spectrum occurs at approximately 600 nm.

(c) One end of a light spring is attached to a ceiling hook and hung vertically. A block of mass 0·1 kg is attached to the lower end. This stretches the spring 1 cm. **5**

(i) Calculate the spring constant, *k*.

(ii) The spring is displaced downwards a further 1 cm and then released.

1. Name the resultant motion.

2. Calculate the frequency of its oscillation.

(iii) The spring is now attached so that the mass oscillates on a smooth table in the horizontal direction.

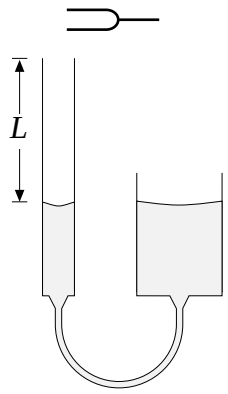
How would the frequency of oscillation now vary from that calculated in part (c) (ii) 2. above?

Question 11 continues on page 30

QUESTION 11. (Continued)

Marks

(d) A tuning-fork is sounded over the mouth of a tube of air. The length (L) of the air column may be varied by raising or lowering a reservoir of water connected to the base of the tube. **4**



For several values of L (the smallest being 15 cm), the air resonates with the frequency of the tuning-fork.

(i) Calculate the frequency of the tuning-fork.

(ii) Draw labelled diagrams of the TWO smallest lengths that produce resonance. Show in each case the distribution of *nodes* and *antinodes* of the standing wave. Indicate the length of each tube.

(e) (i) What is a 'progressive wave'? **6**

(ii) An observer is looking at a particular point on a string along which a wave is travelling.

1. Describe the motion of that point on the string.

2. Draw a displacement–time graph to describe the motion of the point on the string.

   - Label the axes.
   - Label the amplitude.
   - Show an interval on the wave that forms a period.

(iii) A photograph is taken of the string in part (e) (ii) above at a particular instant.

Draw a diagram of this photograph.

Label the:

- axes
- amplitude
- wavelength.

QUESTION 11. (Continued)

Marks

(f) Describe how a sound wave is reflected back along a pipe from the *open* end of the pipe. **2**

(g) Ocean waves are heading for a shoreline at an angle of 45°. They are travelling at 12 m s^{-1}. They encounter a sandbar parallel to the shoreline. As they cross the sandbar, their speed is halved because the speed of the waves depends on the depth of water. **2**

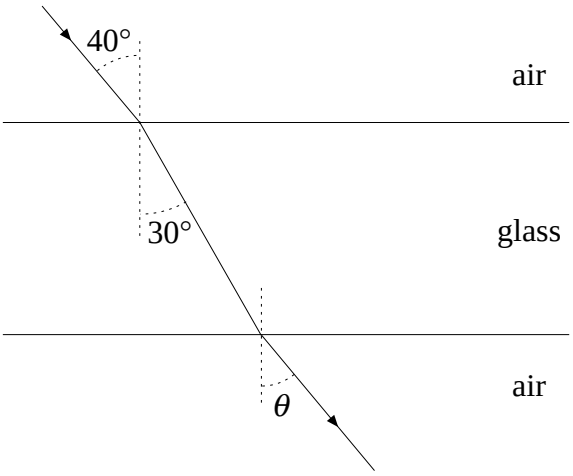
Draw a diagram of this wave formation crossing the sandbar, showing what happens to it as a result of its lower speed.

QUESTION 12. Light

Marks

(a) Describe the propagation of wavefronts in terms of Huygens's principle. **2**

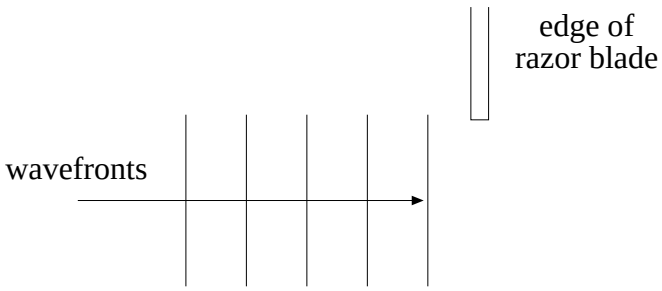
(b) A ray of light passes from air through glass and back into air as shown. **2**



(i) Calculate the value of the refractive index of the glass.

(ii) Determine the value of θ.

(c) Monochromatic light is incident on an edge of a thin razor blade. **4**



(i) Draw a sketch to show the resulting wavefronts as they pass the edge.

(ii) What is the resulting effect called?

(iii) Sketch a light-intensity graph of the resulting pattern. Include the position of the edge on your graph.

QUESTION 12. (Continued)

Marks

(d) Monochromatic light is incident on a pair of slits to produce an interference pattern. **2**

Describe the change in the pattern when:

(i) the width of the slits is made smaller while their separation is kept constant;

(ii) the separation of the slits is made smaller while their width is kept constant.

(e) (i) List TWO characteristics of X-rays. **3**

(ii) How do the characteristics of X-rays support the particle theory of light?

(f) (i) You are provided with two converging-lenses, one of focal length +25 cm and the other of focal length +5 cm. **7**

1. Predict which one gives the greater magnification when used as a magnifying glass with the image formed at infinity.

2. Draw TWO ray diagrams, one for each lens, using the same size object in both to justify your prediction.

(ii) An object is placed 10 cm away from the lens of focal length + 5 cm.

1. Draw a ray diagram to show the position and size of the image formed.

2. Describe the image you would see on a screen placed at the position of the image.

3. It is possible to see an image without the screen. To do so, where would you place your eye?

(iii) The same two lenses are combined to form a telescope. With the aid of a ray diagram, show how the two lenses are to be placed relative to one another to form an image at infinity.

(g) A beam of red light in a narrow band of wavelengths centred on $0{\cdot}66\,\mu$m carries a power of 3·0 mW. How many photons per second are transported by this beam? **2**

Question 12 continues on page 34

QUESTION 12. (Continued)

Marks

(h) The following three quotes illustrate the controversy over the nature of light that lasted for hundreds of years. **3**

> Are not the rays of light very small bodies emitted from shining substances?
>
> ISAAC NEWTON, *Optics*, 1704

> Light is never known to follow crooked passages nor to bend into the shadow . . .
>
> ISAAC NEWTON, *Optics*, 1704

> . . . each little region of a luminous body such as the Sun, a candle, or a burning coal, generates its own waves of which that region is the centre.
>
> HUYGENS, *Treatise on Light*, 1690

Describe THREE pieces of experimental evidence that have helped to resolve this controversy.

GROUP 5—INTERDISCIPLINARY ELECTIVES

Marks

QUESTION 13. Biochemistry

(a) Fructose is a monosaccharide and sucrose is a disaccharide. **3**

(i) Name a natural source of each sugar.

(ii) Give a chemical test to distinguish between glucose and sucrose. What results would you expect from each test?

(b) (i) What process occurs when egg-white is heated? **2**

(ii) Explain this process in terms of changes in the structure of proteins.

(c) Design an experiment to determine *EITHER* the optimum temperature *OR* the optimum pH for a reaction involving an enzyme. **3**

(d) (i) Which of the following equations is a better overall summary of the process of photosynthesis? **3**

Equation 1. $6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$

Equation 2. $12H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$

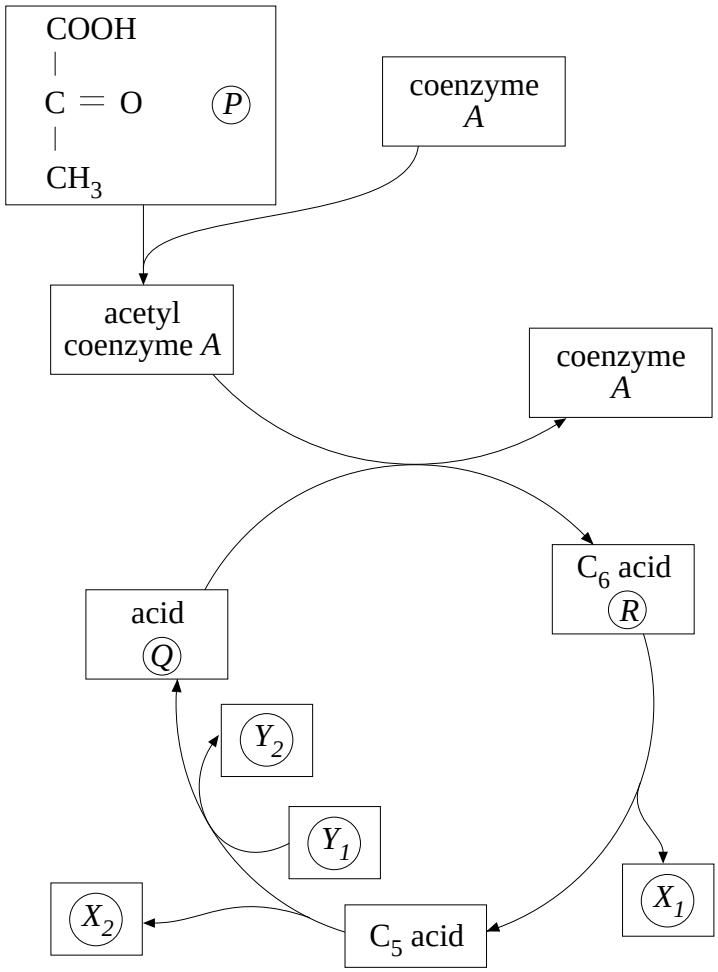
(ii) What evidence supports your conclusion?

Question 13 continues on page 36

QUESTION 13. (Continued)

Marks

(e) The second stage in the oxidative decarboxylation of glucose in a cell is shown. **9**



(i) In which part of the cell does this cycle occur?

(ii) Name substance (P).

(iii) What metabolic pathway has produced (P) from glucose?

(iv) How many carbon atoms are present in acid (Q)? Explain your answer.

(v) This pathway is sometimes named after compound (R).

What is compound (R)?

(vi) Products (X_1) and (X_2) are the same substance.

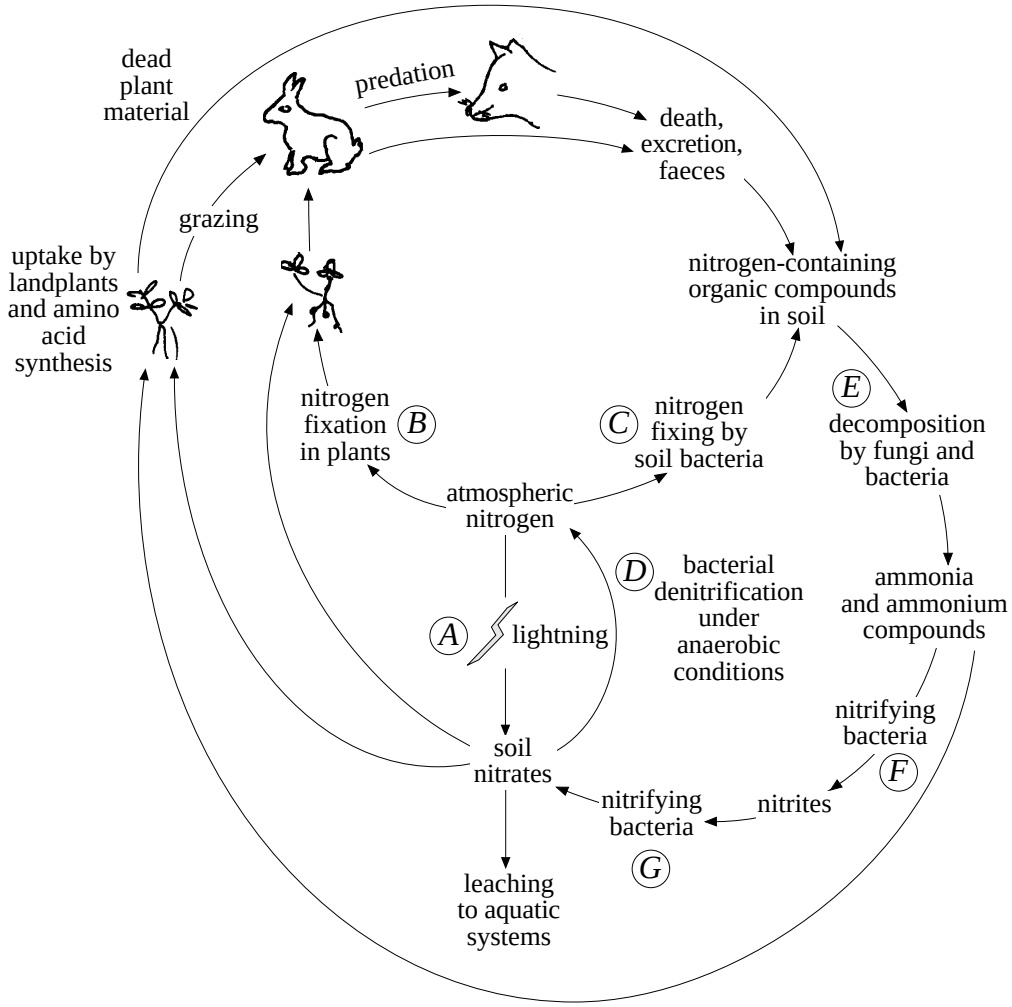
How is it removed from the human body?

(vii) State the function of molecules (Y_1) and (Y_2) in living cells. Describe briefly how they carry out this function.

QUESTION 13. (Continued)

Marks

(f) The diagram shows the nitrogen cycle. **2**



Choose ONE of the stages (A) to (G). State the factors that would affect oxidation or reduction occurring during this stage.

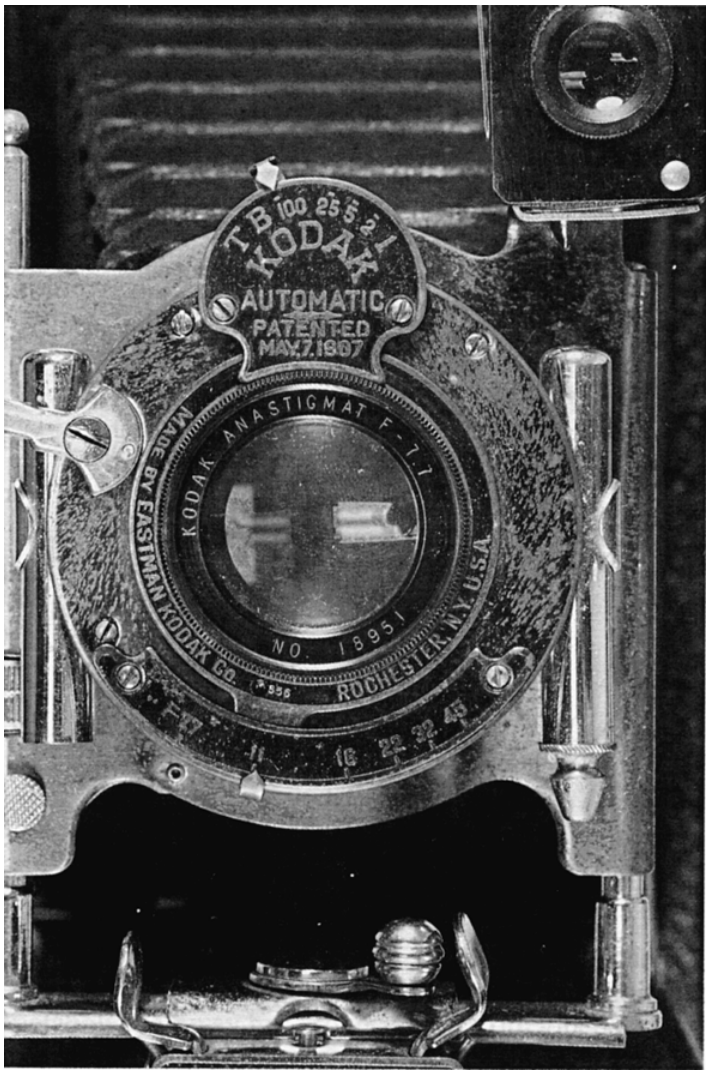
(g) What are the different forms of RNA and what are their functions? **3**

QUESTION 14. Photography

Marks

(a) The photograph shows the lens assembly of an antique camera. **8**

Note that the control scale above the lens is marked T, B, 100, 25, 5, 2, 1 and the control scale below the lens marked *f* 7·7, 11, 16, 22, 32, 45.



(i) What component of the camera system is controlled by the scale marked *f* 7·7 to *f* 45?

(ii) Identify TWO effects of increasing the '*f* ' from 7·7 to 45.

QUESTION 14. (Continued)

Marks

(iii) Cameras like that shown in the photograph were generally used to photograph still subjects on bright, sunny days.

The camera in the photograph would be unsuitable for taking photos of moving subjects in low-light conditions. Give TWO reasons for this.

(iv) Similar controls on a modern camera have scales marked B, 1, 2, 4, 8, 15, 30, 60, 125, 250, 500, 1000, and *f* 2, 2·8, 4, 5·6, 8, 11, 16.

If a setting of 250 gives a correct exposure at *f* 11, what *f* setting would give a correct exposure at 125?

(v) The lens on the antique camera is labelled 'Anastigmat'. This means that it is corrected for one of the more common aberrations of both photographic lenses and human eyes. Modern camera lenses are usually coated and achromatic.

What are the advantages of coated achromatic lenses?

(b) A major film manufacturer produces black and white film in four speeds: ISO (ASA) 25, 100, 400, 1000. **4**

Suggest a suitable use for each of these films. Give a reason for each of your answers.

(c) 35 mm single-lens reflex (SLR) cameras are able to use a wide variety of lenses and accessories. **3**

(i) Give the focal length, in millimetres, of:

1. a wide-angle lens;

2. a telephoto less.

(ii) Describe a use for filters in:

1. black and white photography;

2. colour photography.

Question 14 continues on page 40

QUESTION 14. (Continued)

Marks

(d) Good darkroom technique is required in order to produce clear, clean, and permanent images. Good quality photographs can be destroyed by careless darkroom operations. **5**

(i) Why is it important to load films into developing tanks in *total darkness*, rather than using a 'safe' light?

(ii) Why are temperature and timing critical in developing processes?

(iii) What is the role of agitation in developing film?

(iv) A photography textbook recommends: 'When in doubt, wash everything. Then wash your hands'. Why is cleanliness so important in film processing?

(e) Aerial photographs and satellite images have a wide range of scientific and technical applications. **5**

(i) How is the method of image capture in a Landsat image different from the way in which an aerial photograph is 'taken'?

(ii) Colour prints are often produced from aerial photographs and Landsat images. How do the colours in an aerial photograph differ from those in a Landsat image?

(iii) Give TWO examples of information about the environment that can be interpreted from a colour Landsat image.

QUESTION 15. Physics in Medicine

Marks

(a) The photograph shows detectors for a device being used to make biomedical measurements. **3**

Alexander Tsiaras, Photo Researchers, Inc. New York

(i) Name the measuring-device being used.

(ii) Briefly describe the operation of this measuring-device.

(b) Choose ONE instrument used to measure the temperature of parts of the human body. Explain its operation. **2**

(c) A sphygmomanometer measures blood pressure in an artery. In its use, a cuff is normally wrapped round the upper arm and inflated. **2**

(i) Explain why the cuff is inflated.

(ii) Outline the role of a stethoscope in the measurement of blood pressure.

(d) Ultrasound can be used to investigate foetal condition before a baby is born. **4**

(i) What property of sound waves makes them ultrasonic, or beyond the range of human hearing?

(ii) Explain how ultrasound is used to produce the image of the baby.

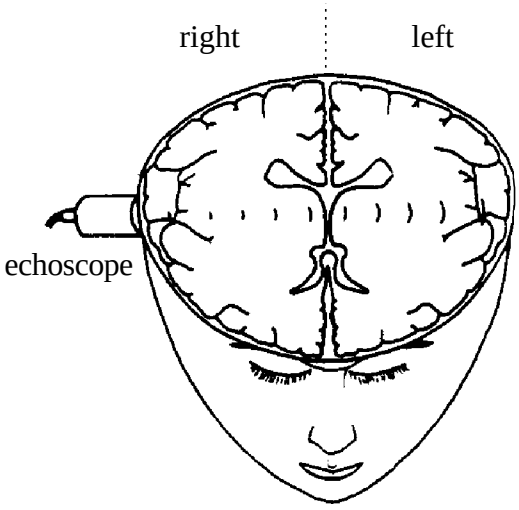
(iii) Explain why ultrasonic scanning is considered a safe method of diagnosis.

Question 15 continues on page 42

QUESTION 15. (Continued)

Marks

(e) The diagram shows an echoscope being used to produce a measurement of the brain. **2**



'Physics' 3rd edition, Kane and Sternheim. © John Wiley 1988.
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Data from the echoscope are shown in the table.

Echo measured from	*Time taken* (s)
right side of skull	$0{\cdot}1 \times 10^{-4}$
midline of brain	$1{\cdot}3 \times 10^{-4}$
left side of skull	$2{\cdot}4 \times 10^{-4}$

Which hemisphere of the brain is enlarged? Explain your answer.

(f) The information in the table below gives the natural background radiation at 1 m above the ground at sea-level. **4**

Radiation	*Source*	*Dose rate* (nGy h^{-1})	*Dose-equivalent rate* (nSv h^{-1})
α	Rn (air)	27	500
β, γ	K, U, Th, Sr (soil)	93	100
β, γ, p, n, μ	cosmic rays (air)	25	30
	TOTAL	145	630

QUESTION 15. (Continued)

Marks

(i) What is meant by ‘dose’?

(ii) Explain how the dose equivalent is obtained from the dose.

(iii) Why is the dose equivalent for radon so large compared with its dose?

(iv) Describe ONE method for monitoring the radiation received in the workplace.

(g) (i) Briefly explain how X-rays are produced in a medical X-ray machine. **3**

(ii) Name ONE safety precaution that the operator of an X-ray machine should follow.

(iii) Name ONE safety precaution that should be taken to protect the patient receiving X-rays.

(h) Outline TWO uses of ionizing radiation in medicine. **2**

(i) Briefly explain ONE application of computer processing in modern medicine. **1**

(j) Describe briefly: **2**

(i) ONE use of fibre optics in medicine;

(ii) ONE use of lasers in medicine.

QUESTION 16. Space Science

Marks

(a) Four of the pioneers of rocketry were: **4**

- Tsiolkovsky
- Goddard
- von Braun
- Oberth.

(i) Select TWO of these pioneers.

(ii) Compare the contributions of the two pioneers you have chosen in terms of:

1. theoretical investigations;

2. practical investigations.

(b) Biosphere 2 is an experimental closed system. It has been set up to imitate conditions in a space station that could be used on Mars. **4**

Explain in detail how such an experiment is applicable to people living:

(i) in a spacecraft;

(ii) on Mars.

(c) Voyager 1 and Voyager 2 greatly expanded our knowledge of the outer planets: Jupiter, Saturn, Uranus, and Neptune. **4**

Select TWO planets. Describe FOUR major discoveries made by Voyagers 1 and 2.

(d) The escape velocity for a rocket on Earth must be more than $1{\cdot}0 \times 10^4$ m s^{-1}. **3**

	Diameter (km)	*Mass* (kg)
Jupiter	142 800	$1{\cdot}9 \times 10^{27}$
Mars	6 787	$6{\cdot}5 \times 10^{23}$

Given that

$$V_{\text{escape}}^2 = 2G \frac{\text{mass}_{\text{planet}}}{\text{radius}_{\text{planet}}},$$

how would the escape velocity from Jupiter and Mars compare to that from Earth?

QUESTION 16. (Continued)

(e) The Earth is surrounded by artificial satellites, situated in numerous orbits round Earth. **2**

(i) Select TWO types of satellite that have different functions.

(ii) Explain in detail why each is so useful to people on Earth.

(f) The Space Shuttle is propelled into space using a liquid-fuel rocket and two solid-fuel rockets. **4**

(i) Why is it necessary to have either a combination of rockets such as the Space Shuttle or multi-stage rockets such as Saturn?

(ii) A rocket of mass 5×10^3 kg is to be launched from Earth. The rocket gases are expelled at 500 m s^{-1}. Immediately after ignition, at what rate (in kg s^{-1}) must the gas be ejected so that the thrust of the rocket is just enough to balance the weight of the rocket?

(g) The Apollo missions to the Moon gathered a great deal of information about it, including a large collection of Moon rocks. **4**

(i) Describe how these Moon rocks have given us information about the Moon's crust.

(ii) Explain a theory about the origin of the Moon.

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DATA SHEET

Values of several numerical constants

Avogadro's constant, N_A	$6{\cdot}022\times10^{23}$ mol^{-1}
Elementary charge, e	$1{\cdot}602\times10^{-19}$ C
Faraday constant, F	96 490 C mol^{-1}
Gas constant, R	8·314 J K^{-1} mol^{-1} 0·0821 L atm K^{-1} mol^{-1}
Mass of electron, m_e	$9{\cdot}109\times10^{-31}$ kg
Mass of neutron, m_n	$1{\cdot}675\times10^{-27}$ kg
Mass of proton, m_p	$1{\cdot}673\times10^{-27}$ kg
Volume of 1 mole ideal gas	
at 101·3 kPa (1 atm) and	
at 273 K (0°C)	22·41 L
at 298 K (25°C)	24·47 L

Earth's gravitational acceleration, g	9·8 m s^{-2}
Speed of light, c	$3{\cdot}0\times10^{8}$ m s^{-1}
Coulomb's constant, k	$9{\cdot}0\times10^{9}$ m V C^{-1}
Permeability constant, μ_0	$4\pi\times10^{-7}$ N A^{-2}
Universal gravitation constant, G	$6{\cdot}7\times10^{-11}$ N m^2 kg^{-2}
Mass of Earth	$6{\cdot}0\times10^{24}$ kg
Radius of Earth	6378 km
Planck's constant, h	$6{\cdot}626\times10^{-34}$ J s
Density of water	10^3 kg m^{-3}
Specific heat of water	4180 J kg^{-1} K^{-1}
Speed of sound in air	330 m s^{-1}

Some Standard Potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2·92 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2·90 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2·87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2·71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2·36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1·66 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1·18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0·83 V
$Cd(OH)_2(s) + 2e^-$	$\rightleftharpoons$	$Cd(s) + 2OH^-(aq)$	–0·81 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0·76 V
$S(s) + 2e^-$	$\rightleftharpoons$	S^{2-}	–0·48 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0·41 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0·23 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0·14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0·13 V
$CO_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$HCHO + H_2O$	–0·07 V
$CO_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$\frac{1}{6}C_6H_{12}O_6$ (glucose) $+ H_2O$	–0·01 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0·00 V
$CO_2(g) + 6H^+ + 6e^-$	$\rightleftharpoons$	$CH_3OH + H_2O$	0·03 V
$CO_2(g) + 8H^+ + 8e^-$	$\rightleftharpoons$	$CH_4(g) + 2H_2O$	0·17 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	0·21 V
$HCHO + 2H^+ + 2e^-$	$\rightleftharpoons$	CH_3OH	0·24 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0·35 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0·40 V
$HCHO + 4H^+ + 4e^-$	$\rightleftharpoons$	$CH_4(g) + H_2O$	0·41 V
$NiO_2(s) + 2H_2O + 2e^-$	$\rightleftharpoons$	$Ni(OH)_2(s) + 2OH^-$	0·49 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0·52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0·54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0·62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0·77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0·80 V
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	0·96 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1·07 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1·09 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1·23 V
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	1·33 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1·36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1·40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1·51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2·87 V

PERIODIC TABLE

KEY

Atomic Number
Atomic Mass
Symbol of element
Name of element

																	2 He 4·003 Helium
3 Li 6·941 Lithium	4 Be 9·012 Beryllium				79 Au 197·0 Gold				1 H 1·008 Hydrogen			5 B 10·81 Boron	6 C 12·01 Carbon	7 N 14·01 Nitrogen	8 O 16·00 Oxygen	9 F 19·00 Fluorine	10 Ne 20·18 Neon
11 Na 22·99 Sodium	12 Mg 24·31 Magnesium											13 Al 26·98 Aluminium	14 Si 28·09 Silicon	15 P 30·97 Phosphorus	16 S 32·06 Sulfur	17 Cl 35·45 Chlorine	18 Ar 39·95 Argon
19 K 39·10 Potassium	20 Ca 40·08 Calcium	21 Sc 44·96 Scandium	22 Ti 47·90 Titanium	23 V 50·94 Vanadium	24 Cr 52·00 Chromium	25 Mn 54·94 Manganese	26 Fe 55·85 Iron	27 Co 58·93 Cobalt	28 Ni 58·71 Nickel	29 Cu 63·55 Copper	30 Zn 65·38 Zinc	31 Ga 69·72 Gallium	32 Ge 72·59 Germanium	33 As 74·92 Arsenic	34 Se 78·96 Selenium	35 Br 79·90 Bromine	36 Kr 83·80 Krypton
37 Rb 85·47 Rubidium	38 Sr 87·62 Strontium	39 Y 88·91 Yttrium	40 Zr 91·22 Zirconium	41 Nb 92·91 Niobium	42 Mo 95·94 Molybdenum	43 Tc 98·91 Technetium	44 Ru 101·1 Ruthenium	45 Rh 102·9 Rhodium	46 Pd 106·4 Palladium	47 Ag 107·9 Silver	48 Cd 112·4 Cadmium	49 In 114·8 Indium	50 Sn 118·7 Tin	51 Sb 121·8 Antimony	52 Te 127·6 Tellurium	53 I 126·9 Iodine	54 Xe 131·3 Xenon
55 Cs 132·9 Cesium	56 Ba 137·3 Barium	57 La 138·9 Lanthanum	72 Hf 178·5 Hafnium	73 Ta 180·9 Tantalum	74 W 183·9 Tungsten	75 Re 186·2 Rhenium	76 Os 190·2 Osmium	77 Ir 192·2 Iridium	78 Pt 195·1 Platinum	79 Au 197·0 Gold	80 Hg 200·6 Mercury	81 Tl 204·4 Thallium	82 Pb 207·2 Lead	83 Bi 209·0 Bismuth	84 Po — Polonium	85 At — Astatine	86 Rn — Radon
87 Fr — Francium	88 Ra 226·0 Radium	89 Ac — Actinium	104	105	106												

58 Ce 140·1 Cerium	59 Pr 140·9 Praseodymium	60 Nd 144·2 Neodymium	61 Pm — Promethium	62 Sm 150·4 Samarium	63 Eu 152·0 Europium	64 Gd 157·3 Gadolinium	65 Tb 158·9 Terbium	66 Dy 162·5 Dysprosium	67 Ho 164·9 Holmium	68 Er 167·3 Erbium	69 Tm 168·9 Thulium	70 Yb 173·0 Ytterbium	71 Lu 175·0 Lutetium
90 Th 232·0 Thorium	91 Pa 231·0 Protactinium	92 U 238·0 Uranium	93 Np 237·0 Neptunium	94 Pu — Plutonium	95 Am — Americium	96 Cm — Curium	97 Bk — Berkelium	98 Cf — Californium	99 Es — Einsteinium	100 Fm — Fermium	101 Md — Mendelevium	102 No — Nobelium	103 Lr — Lawrencium

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STUDENT NUMBER

CENTRE NUMBER

HIGHER SCHOOL CERTIFICATE EXAMINATION

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ALL COURSES

ELECTIVES/MODULES ANSWER BOOK

COURSE	NAME OF ELECTIVE / MODULE	QUESTION / MODULE NUMBER

DIRECTIONS TO CANDIDATES

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- In the table above:
  - (i) write the name of the course you are doing;
  - (ii) write the name of the Elective/Module you are answering;
  - (iii) write the Question/Module Number of the Elective/Module you are answering.
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