BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1997

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 Data Sheet and Periodic Table are provided as a tear-out sheet at the back of this paper.
- Board-approved calculators may be used.

CONTENTS

GROUP 1—BIOLOGY ELECTIVES

Marks

QUESTION 1. Flowering Plants and Mammals

(a) (i) Why is carbon dioxide needed by plants? **5**

(ii) Draw a simple, labelled diagram showing a stomate.

(iii) Explain how stomates control carbon dioxide uptake.

(iv) The movement of other substances into and out of plants may also be controlled by stomates. List TWO of these substances.

(b) Xylem tissue possesses specific features which enable it to carry out its specialised functions. **2**

(i) List TWO physical features of xylem tissue that enable it to carry out its function.

(ii) Explain how each of these features assists the function of xylem.

(c) The concentration of minerals in the root cells of plants may be many times the concentration in the surrounding soil. **3**

(i) Name and describe the cellular process used to achieve this.

(ii) Explain how this process differs from the uptake of water by the root cells.

(d) (i) What are the products of the digestion of protein? **3**

(ii) Trace the path taken by the products of protein digestion to body cells.

(e) Explain how oxygen and carbon dioxide are transported in human blood. **3**

(f) (i) Define homeostasis. **4**

(ii) State ONE process that is under homeostatic control in mammals.

(iii) Using a flow diagram, describe both the input and output sides of the process named in part (f) (ii).

(g) Using an example of ONE plant hormone and ONE mammal hormone, construct and complete a table showing: **5**

(i) the mode of transport of the hormone;

(ii) the target organ or tissue;

(iii) the organism’s response.

QUESTION 2. Reproduction and Genetics **Marks**

(a) Describe ONE way in which plant and animal reproduction is *different to* reproduction in: **2**

(i) bacteria;

(ii) viruses.

(b) (i) What is ONE advantage of sexual reproduction to a species? **3**

(ii) Explain how sexual reproduction enables the development of new species.

(c) (i) What is tissue culture? **3**

(ii) Describe ONE application of tissue culture.

(iii) Describe ONE advantage of tissue culture over alternative techniques.

(d) (i) Define the term *plasmid*. **4**

(ii) Describe, using an example, how plasmids are used in recombinant DNA techniques. Diagrams may be useful.

(e) (i) Explain the term *linked genes.* Include a diagram in your answer. **4**

(ii) Briefly describe an experiment that could be carried out to determine if two genes are linked.

(f) In a species of plant, purple flowers are dominant over white flowers, and long pollen grains are dominant over short pollen grains. **3**

A plant with purple flowers and short pollen grains was crossed with a plant with white flowers and long pollen grains.

The resulting offspring were as follows:

- purple flowers, long pollen grains: 166
- purple flowers, short pollen grains: 176
- white flowers, long pollen grains: 161
- white flowers, short pollen grains: 175

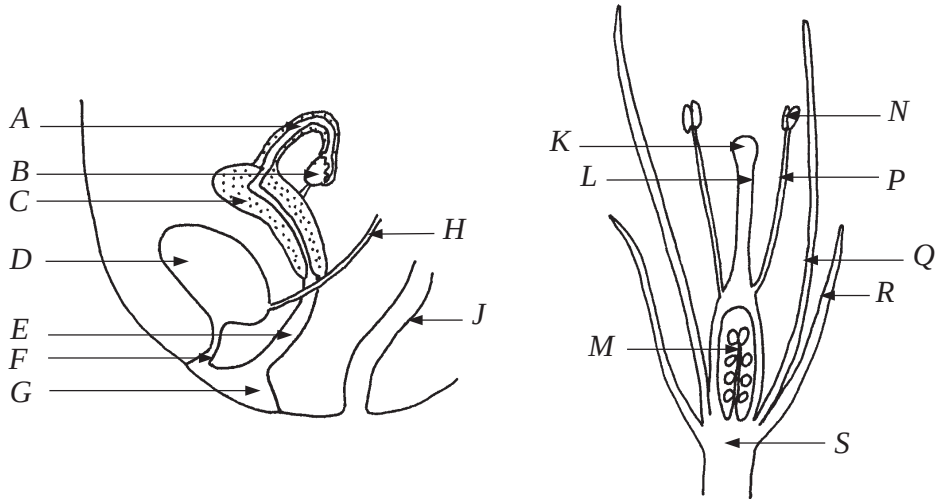
Use a diagram to determine the genotypes of the parent plants used in this cross.

(i) State the genotypes of the parent plants.

(ii) Use a diagram (such as a punnet square) to show the genotypes of the offspring.

QUESTION 2. (Continued) **Marks**

(g) The diagrams show the reproductive system in a human female and a flower. **2**



List the labels from each diagram that indicate the organs

(i) that produce gametes;

(ii) where fertilisation occurs.

(h) Describe **2**

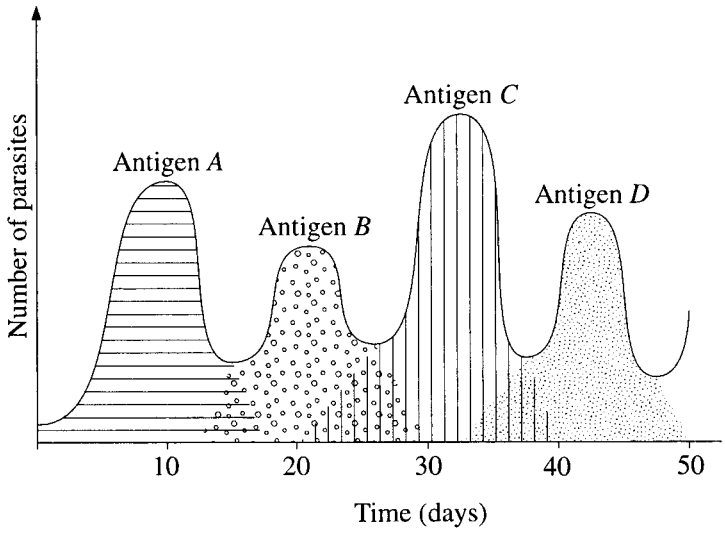
(i) ONE similarity between a gamete and a spore;

(ii) ONE difference between a gamete and a spore.

(i) Describe the process used in cells to transmit genetic information from the nucleus to the ribosomes during protein synthesis. **2**

QUESTION 3. Micro-organisms and Disease **Marks**

(a) The figure below shows numbers of one type of parasite in the blood of its host. The parasite has a surface covering that consists of a single antigen. This covering can change over time. **4**



Provide ONE explanation for the cyclic changes in the number of parasites, based on the ability of the immune system to respond to this parasite.

(b) (i) List TWO mechanisms of dispersal used by disease-causing organisms. **5**

(ii) For each mechanism listed in part (b) (i), describe a method used to control the dispersal.

(c) This question refers to viruses, bacteria, fungi, and animal cells. **4**

State which of the following structures EACH of the above possesses.

- Nucleus
- Mitochondria
- Cell membrane
- Cell wall.

(d) Explain how the immune response can be used to control some diseases through immunisation. **3**

QUESTION 3. (Continued) **Marks**

(e) Scientists are concerned about the potential devastation that could be caused by virus diseases. **6**

(i) Explain ONE problem associated with the treatment of virus diseases.

(ii) At present the rabbit *calici* virus is being released in Australia to control rabbit populations. Why might scientists be concerned about the potential harm that could be caused to other species in the release of this virus?

(iii) Describe how viruses can be cultured.

(f) Describe ONE mechanism used by plants to prevent or overcome both bacterial and fungal pathogens. **2**

(g) Bacteria are often grown in test-tubes on agar slopes. What is the advantage of having the agar sloped? **1**

QUESTION 4. Coordination and Control **Marks**

(a) Read the following passage. **5**

> Plant Hormones Jail Jack
>
> At the theft and damages trial, scientific evidence emerged concerning the growth of Jack's giant beanstalk. Bioanalysis suggested massive over-production of normal hormones had produced the giant plant. Evidence showed that of the three seeds planted, two were destroyed by Jack's mother when mowing the back lawn. The third plant was apparently flattened but straightened itself under the influence of tropism and *hormone A*. Damage to neighbouring properties was caused by huge axillary (side) buds resulting from increasing levels of *hormone B* although the massive stalk itself was primarily due to the influence of *hormone C*. Jack's hopes for paying his legal costs and damages through the sale of the massive and beautiful flowers promoted by *hormone D* (the beans were 'woody' and inedible) were unfortunately ruined. A severe frost destroyed the plant, even though it produced ample amounts of stress *hormone E*. The withered plant finally fell on Jack's home.

(i) Give the names of the plant hormones: *A*, *B*, *C*, *D*, and *E*.

(ii) Explain how *hormone A* produced the effect described in the passage.

(b) (i) Name the TWO major tissues that make up the central nervous system. **5**

(ii) Compare and contrast the control of heart muscle and skeletal muscle by the nervous system.

(iii) Name the major substance present in the insulating sheath of peripheral neurones.

(c) Compare and contrast the roles of hormones and nerves in maintaining homeostasis. **4**

QUESTION 4. (Continued) **Marks**

(d) An experiment was conducted on short-day and long-day plant species. Three different experimental conditions were used. The results of these experiments are shown in the diagram below. **5**

(i) Describe the relationship between the response of the plants and the light conditions.

(ii) Suggest a hypothesis that could be used to explain this relationship.

(e) Draw a labelled diagram of a neurone. Use arrows to show the direction of nerve impulse. **3**

(f) Construct a table listing THREE animal hormones, an organ or tissue that produces each one, and the major function associated with each hormone listed. **3**

GROUP 2—CHEMISTRY ELECTIVES

Marks

QUESTION 5. Energy

Include physical states in all equations.

(a) (i) Copy and complete the following table in the Answer Book. **6**

Fuel	*Major domestic use*	*Major industrial use*
ethene		
propane		
coke		

(ii) List and define THREE properties that can be used to classify fuels.

(b) (i) Use the information below to calculate H° for the following reaction: **6**

$$10C(g) + 4H_2O(g) \rightarrow C_{10}H_8(s) + 2O_2(g).$$

Given:

- standard heat of atomisation of C(*s*) 717 kJ mol^{-1}
- standard heat of combustion for C(*s*) 394 kJ mol^{-1}
- standard heat of combustion for $C_{10}H_8(s)$ 5156 kJ mol^{-1}
- standard heat of formation of $H_2O(l)$ –286 kJ mol^{-1}
- standard heat of vaporisation of $H_2O(l)$ 44 kJ mol^{-1}

(ii) What conditions determine H° for a reaction?

QUESTION 5. (Continued) **Marks**

(c) A student carried out two experiments involving electrolysis. **9**

In *Experiment I*, a 1·0 mol L^{-1} sodium chloride solution was electrolysed. Bubbles of gas were produced at both electrodes.

(i) Draw a *fully labelled* diagram of the equipment used for the electrolysis reaction.

(ii) Justify your choice of material for each electrode.

(iii) Write the half-cell reaction that occurs at the

1. cathode;

2. anode.

(iv) Calculate the minimum voltage required for the electrolysis reaction to occur.

(v) Describe a test to identify each of the gases produced in part (iii).

In *Experiment II*, molten sodium chloride is electrolysed for 30 minutes, using a current of 2·5 amps.

(vi) What products are formed at the

1. cathode;

2. anode.

(vii) Calculate the quantity of charge that will be transferred during the 30 minutes.

(d) A student wanted to find out how much heat is produced when 5·00 g sodium hydroxide pellets are dissolved in water. The student placed 5·00 g of the pellets in 101 mL of water, at 24·6°C, contained in a calorimeter. The solution reached a maximum temperature of 37·1°C. **4**

(i) Write the general formula used to calculate the heat change for this reaction.

(ii) What is the total mass of the solution in the calorimeter?

(iii) Calculate the amount of heat produced by dissolving 5·00 g of the sodium hydroxide in water.

(iv) Calculate the solution energy for the sodium hydroxide pellets.

QUESTION 6. Atomic Structure and the Periodic Table **Marks**

(a) The following are orbital representations of some elements. **10**

V $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

W $1s^2\ 2s^2\ 2p^5$

X $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

Y $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Z $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

(i) Identify each element.

(ii) Which of the above elements is an inert gas? Justify your choice.

(iii) Which of the above elements displays the strongest tendency to form anions? Justify your choice.

(iv) ONE of the above elements forms compounds of variable valency. Identify this element, and explain your choice.

(v) Give the orbital representation of the common ionic form of element *Z*.

(vi) 1. With reference to $2p^6$, describe what is meant by 2, *p*, and 6.

2. Draw the pictorial representation of the *p* orbitals.

(b) Beryllium forms stable compounds but helium does not, even though the structure of their outer filled orbitals is the same. Explain this. **1**

(c) (i) Describe how the chemical activity of the elements in Group 1 (excluding the first element in the group) varies. Refer to specific chemical reactions. **4**

(ii) Explain why the first element in Group 1 does not follow the trend in chemical activity.

(iii) Explain why Group 1 is classed as an ‘*s*-block’ group.

QUESTION 6. (Continued) **Marks**

(d) The following historical statements relate to the development of the atomic model. **10**

- *Statement V*
  'The total energy of an electron in an atom is quantised. Electrons move about the nucleus in circular orbits. The location and momentum of electrons are known.'

- *Statement W*
  'The atom is a sphere of positive charge with negative electrons in it. The mass of the atom is associated with the positive charge.'

- *Statement X*
  'The neutron has zero electric charge, the same mass as a hydrogen atom, and is found in the nucleus of an atom.'

- *Statement Y*
  'The mass and positive charge of an atom are concentrated in the nucleus that occupies a very small part of the total volume of the atom. The rest of the volume of the atom is occupied by the electrons.'

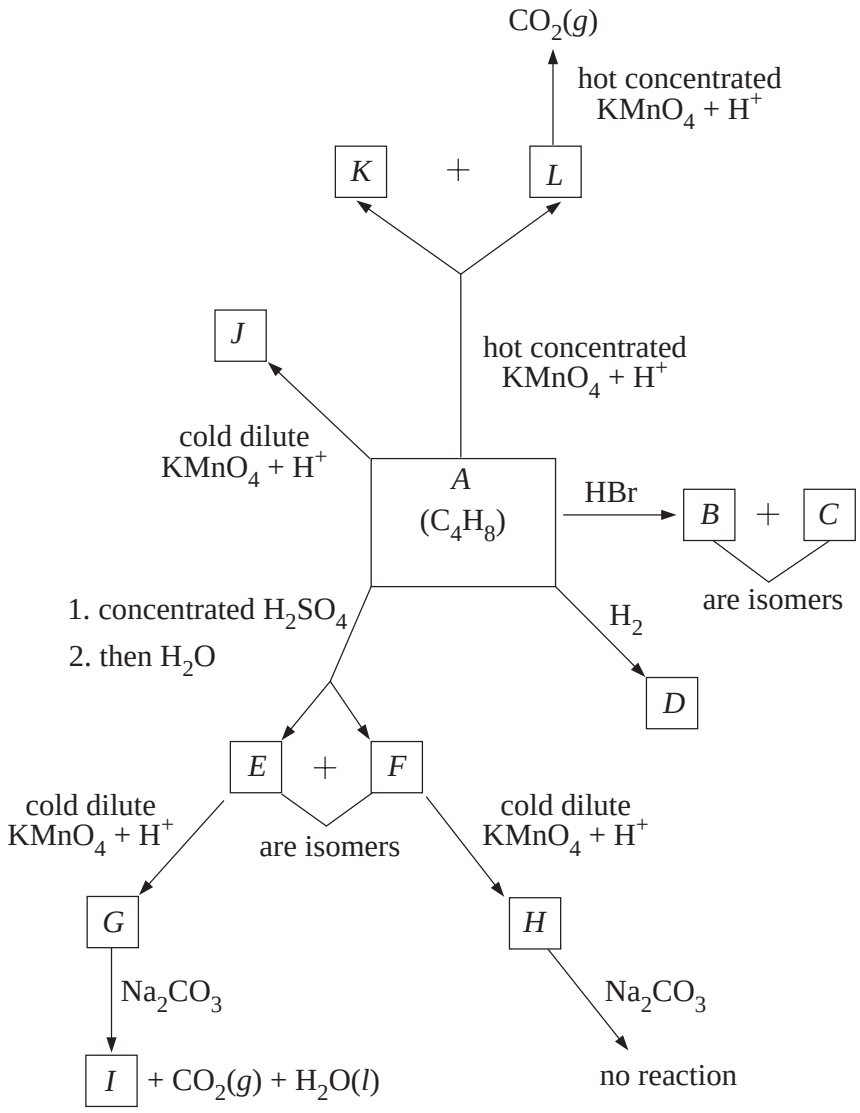
- *Statement Z*
  'A wave equation can be used to describe the motion of the electrons in an atom. Solutions to the wave equation are whole numbers, called quantum numbers, that describe the energy levels of the electrons.'

(i) Name the scientist who is credited with each statement.

(ii) Describe how each of these scientists contributed to the changes in understanding of the structure of the atom.

QUESTION 7. Carbon Chemistry **Marks**

(a) This question refers to the diagram below. **15**



QUESTION 7. (Continued) **Marks**

(i) Name and give the structural formula for each of the compounds *A* to *L*.

(ii) Describe a chemical test that would differentiate between compounds *A* and *D*. What observations will confirm your test?

(iii) Write down any relevant chemical equations for reactions that may occur in the test described in part (ii). Include conditions.

(b) (i) Write the equation for the dehydration of ethanol. Include reagents and conditions. **3**

(ii) What is a major industrial use of ethanol?

(iii) Name the process that a school student would use to make ethanol. Write the equation for this process. Include conditions.

(c) An organic chemist mixed l-butanol, ethanoic acid, and concentrated sulfuric acid in a flask to make an ester. The mixture was refluxed for 1 hour, using safety precautions. After refluxing, the chemist wanted to isolate the ester. The mixture was transferred to a separating funnel. A number of cleaning procedures were carried out. Once cleaned, the resulting dry liquid was distilled to obtain a pure ester. **7**

(i) Write a balanced equation for the production of the ester.

(ii) Give the IUPAC nomenclature for the ester.

(iii) Draw a fully labelled diagram of the equipment used for refluxing.

(iv) Why is the reflux procedure used to make an ester?

(v) Describe TWO cleaning procedures that the organic chemist will carry out using the separating funnel.

GROUP 3—GEOLOGY ELECTIVES

Marks

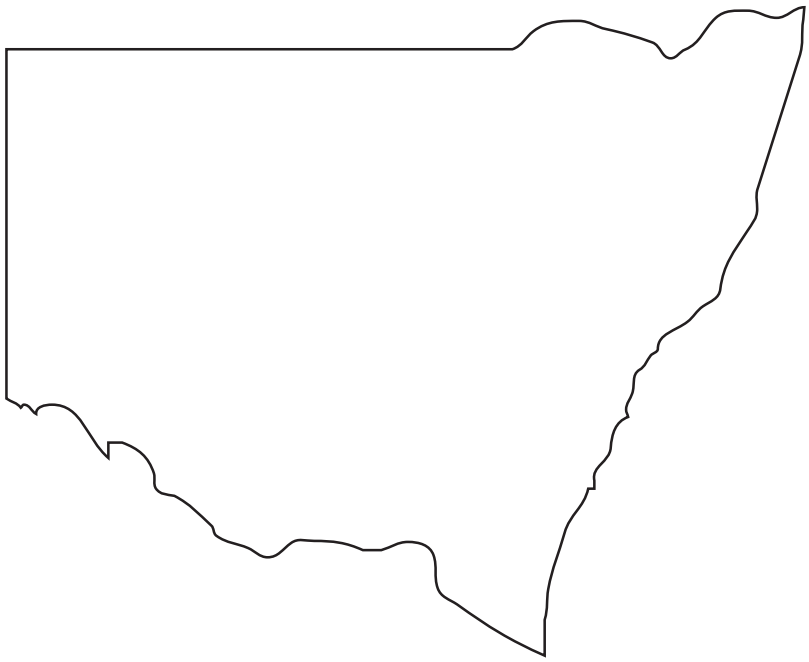
QUESTION 8. Regional Geology

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.

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

(b) Copy the map of New South Wales below into your Answer Book **5**



(i) Draw onto the map the region you have studied, *and* an adjoining region, with appropriate labels.

(ii) Draw the main structural features of the region on your map.

(iii) Describe the main structural characteristics of the region you have studied.

(iv) Name the geological structure that forms the boundary between the adjoining regions named in part (i).

QUESTION 8. (Continued) **Marks**

(c) Draw a labelled stratigraphic column showing the rock units in the region you have studied, including: **4**

(i) the major rock units in their correct stratigraphic order;

(ii) the age (geological periods) in which the rock units formed.

(d) (i) Name the geological or tectonic event that was of major significance in the evolution of the region you have studied. **5**

(ii) Name the geological period in which the significant event named in part (d) (i) occurred.

(iii) Describe the actions of the significant event named in part (d) (i) and explain how the event has contributed to the present geological make-up of the region.

(e) Describe the geomorphology of the region you have studied, and discuss its nature with respect to the different rock units. **3**

(f) (i) Name an economic resource recovered from the region you have studied. **4**

(ii) Explain why this resource is economically useful.

(iii) Describe the mining/extraction method(s) used to recover the resource.

(g) A feature of special geological interest could include an archaeological or palaeontological site, an artesian system, a civil engineering project, or a scenically spectacular feature.

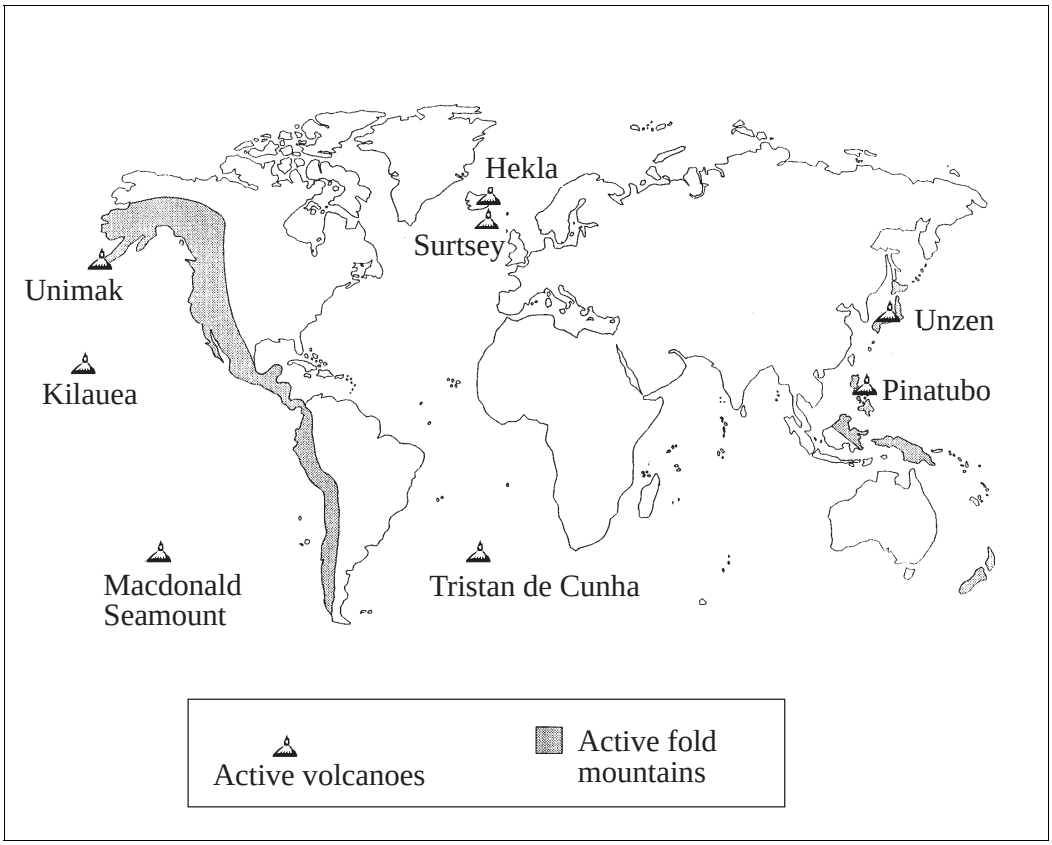
(i) Name a feature of special geological interest in the region you have studied. **4**

(ii) Explain why the feature is of special interest.

(iii) Describe the formation of the feature.

QUESTION 9. Mountains **Marks**

The map below shows the location of some active volcanoes and fold mountain belts.



QUESTION 9. (Continued) **Marks**

(a) The world's active volcanoes can be divided into three broad groups. The volcanoes shown on the map on page 18 are some that have been active in recent times. They are divided into the three groups in the table below. **1 2**

Group 1	Unzen, Japan; Pinatubo, Philippines; Unimak, Aleutian Islands.
Group 2	Hekla, Iceland; Surtsey, Vestmann Islands; Tristan da Cunha, South Atlantic.
Group 3	Kilauea, Hawaii; Macdonald Seamount, South Pacific.

Copy and complete the following table into your Answer Book.

	Group 1	Group 2	Group 3
Plate tectonic setting			
Magma composition			
Style of volcanism			
Typical volcanic landforms			

Question 9 continues on page 20

QUESTION 9. (Continued) **Marks**

(b) Much of the world's active mountain building, as shown on the map on page 18, is taking place on the margins of some continents. **7**

(i) Which of the world's oceans is encircled by fold mountain building?

(ii) Draw a labelled cross-section through a continental margin fold mountain system, to illustrate the main tectonic and geological features present.

(iii) Describe the types of rocks that occur in fold mountains.

(iv) Describe a structure, other than a fold, that could be found in fold mountains.

(c) (i) Explain the formation of shield areas. **6**

(ii) Describe the tectonic setting of shield areas.

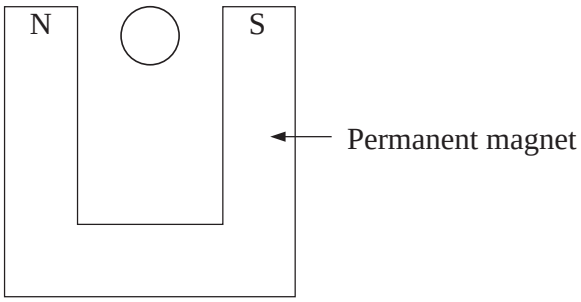
(iii) Describe the geomorphology of shield areas.

GROUP 4—PHYSICS ELECTIVES

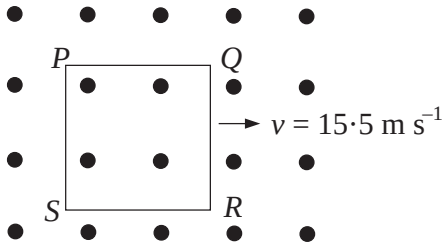
Marks

QUESTION 10. Electromagnetism

(a) A circular conductor is placed in a magnetic field as shown. State TWO ways of inducing a current in this conductor. **2**



(b) A square wire loop *PQRS* moves through a magnetic field of strength 0·600 T at 15·5 m s^{-1} as shown in the diagram drawn to scale. **4**



(i) What is the e.m.f. induced across the sides:

1. *PQ*?
2. *QR*?
3. *PS*?

(ii) Will a current flow in this loop of wire? Explain your answer.

(c) An electron enters a magnetic field of flux density 0·85 T at an angle of 42°. It experiences a force of $4{\cdot}5 \times 10^{-12}$ N. **3**

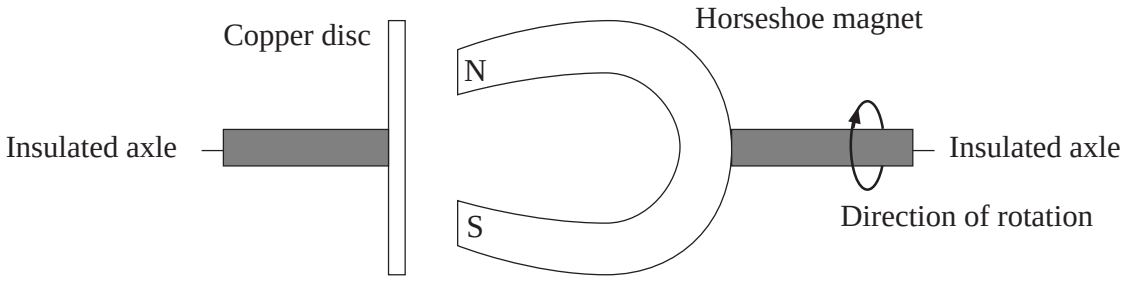
(i) Determine the velocity of the electron.

(ii) Describe the path taken by the electron. Use a diagram to illustrate your answer.

Question 10 continues on page 22

QUESTION 10. (Continued) **Marks**

(d) A circular disc of copper, and a horseshoe magnet, are mounted as shown. The disc and magnet are free to rotate on their respective axles. **3**



Describe and explain what happens when the magnet is rotated.

(e) A student set up a series circuit consisting of a globe, a transformer set on 12V DC, and a solenoid of 800 turns. Some soft iron rods were placed inside, but not touching the solenoid. **3**

The experiment was repeated with the transformer set to 12V AC. The student observed that the globe was dimmer and the temperature of the rods increased.

Explain the student's observations.

(f) A solenoid of 380 turns and cross-sectional area 5 cm^2 has a magnetic flux density of 1·5 T inside the solenoid. Calculate **2**

(i) the magnetic flux inside the solenoid;

(ii) the current in the solenoid.

(g) What are TWO applications of the torque on a coil in a magnetic field? **2**

(h) (i) Calculate the force on a 180 m length of wire stretched between two towers and carrying a 280 amp current. The wire makes an angle of 60·0° to the earth's magnetic field of strength 2×10^{-5} T. **4**

(ii) Draw the magnetic field lines around the wire that is carrying the current.

(i) Explain how continuous rotation is maintained by the coil of a simple DC electric motor. (A diagram may be included.) **2**

QUESTION 11. Oscillations and Waves **Marks**

(a) The smallest radius of the orbiting electron in a hydrogen atom is $0{\cdot}53 \times 10^{-10}$ m. The electron moves with a speed of $6{\cdot}00 \times 10^{6}$ m s^{-1}. Calculate **4**

(i) the angular velocity of the electron;

(ii) the period of the electron;

(iii) the centripetal acceleration of the electron;

(iv) the centripetal force on the electron.

(b) An insect of mass 0·75 g is caught in a spider's web. The web vibrates through an amplitude of 5·0 mm in simple harmonic motion with a frequency of 2·9 Hz. **7**

(i) Determine the force (spring) constant of the web.

(ii) Describe the energy changes in the web as it vibrates.

(iii) Draw the displacement–time graph that represents this motion. Include numerical data.

(iv The web is attached to a tree branch that begins vibrating at 2·9 Hz, due to a breeze. The amplitude of the web's vibration increases markedly. Name this effect, and explain why it occurs.

(c) A horizontal metal bar is being hit with a hammer. **2**

Name and describe the types of waves that travel along the bar when it is hit repeatedly

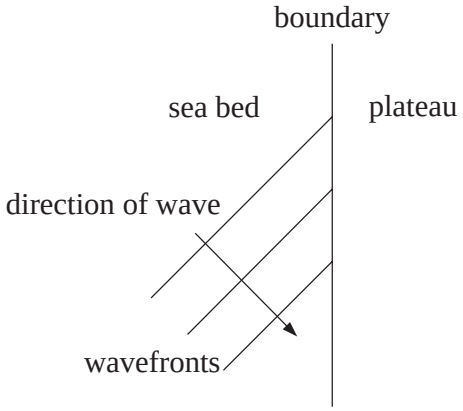
(i) on the end, horizontally;

(ii) on the side, vertically.

Question 11 continues on page 24

QUESTION 11. (Continued) **Marks**

(d) Water waves travelling at $3{\cdot}2$ m s^{-1} with a frequency of 15 Hz approach an underwater plateau, as shown in the diagram. The plateau is higher than the surrounding sea bed. **5**



(i) Determine the wavelength of the waves passing over the seabed.

(ii) Describe TWO changes to the waves at the boundary.

(iii) Copy the diagram into your Answer Book.

Draw a series of:

1. reflected wavefronts;

2. refracted wavefronts.

Label the wavefronts and show the directions of propagation.

(iv) What happens to the energy of the wave at the boundary?

(e) An AM radio station has a wavelength of 233 m and a local FM radio station has a wavelength of $3{\cdot}2$ m. AM radio stations can usually be detected even when there is an obstruction, such as a hill between the transmitter and the receiver. **2**

(i) What property of radio waves can be used to explain this observation?

(ii) FM signals often cannot be detected in similar situations. Explain this observation.

(f) A violin string is tuned to a fundamental frequency of 440 Hz. A wave of speed 285 m s^{-1} travels along it. **5**

(i) Determine the length of the string.

(ii) Calculate the length of a closed organ pipe that would produce the same fundamental note.

(iii) Draw diagrams to illustrate the first overtone mode of vibration of:

1. the violin string;

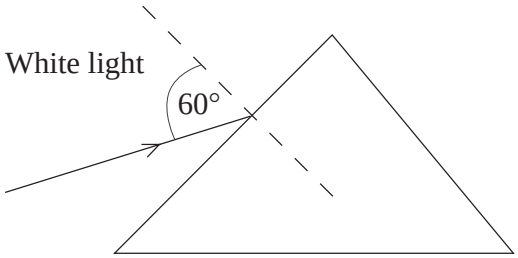
2. the closed organ pipe.

QUESTION 12. Light **Marks**

(a) (i) Using Huygens' principle, draw a labelled diagram to explain the refraction of light as it passes from water to air. The angle of incidence is 30°. **3**

(ii) When you look down into a pool of water, are you likely to underestimate or overestimate the depth? Explain your answer. A diagram may be helpful.

(b) White light is incident on a glass prism as shown. **6**



When the white beam is refracted in the glass it disperses. A spectrum including a blue ray and a red ray with velocities $1{\cdot}90 \times 10^8$ m s^{-1} and $1{\cdot}95 \times 10^8$ m s^{-1} respectively, is observed.

(i) Calculate the angle of dispersion *in the glass*, that is, the angle between the blue and red rays.

(ii) Copy the diagram into your Answer Book and complete it to show the spectrum of light emerging from the prism. Label the blue and red rays.

(iii) A spectrum can also be produced by shining white light on a double-slit apparatus.

With the aid of a diagram showing the blue and red rays, explain how the spectrum is produced.

Question 12 continues on page 26

QUESTION 12. (Continued) **Marks**

(c) (i) Describe ONE difference between real and virtual images. **8**

(ii) Light from a star enters a convex lens of focal length 38 cm.

1. Show how this lens could be used as the objective lens in a refracting telescope. Use a labelled ray diagram.

2. Show how a second lens of focal length 5 cm could be used to complete the telescope.

(iii) A microscope also uses two lenses. Give ONE difference between the lenses used in microscopes and telescopes. Give a reason for this difference.

(iv) The magnification and resolution of a microscope is limited by diffraction effects. Describe the appearance of an image as the magnification increases.

(d) (i) Describe ONE example of the photoelectric effect. **2**

(ii) How does the photoelectric effect conflict with the results of Young's double-slit experiment?

(e) In photosynthesis, *chlorophyll a* in plants is used with energy from the sun to fix CO_2 into carbohydrates. **4**

(i) Assuming that 9 photons are needed for the fixation of each CO_2 molecule, and that the wavelength of useful light is 675 nm, determine the energy required to convert each CO_2 molecule into carbohydrates.

$$E = \frac{hc}{\lambda}$$

(ii) Explain why *chlorophyll a* cannot absorb energy with wavelengths outside the range 600 to 700 nm.

(f) Three forms of electromagnetic radiation are ultraviolet rays, X-rays, and γ–rays. Which of these has the greatest energy? Explain your answer. **2**

GROUP 5—INTERDISCIPLINARY ELECTIVES

Marks

QUESTION 13. Biochemistry

(a) (i) Under the same physical conditions, two different enzymes can affect the same reaction. Explain why one enzyme may start having an effect before the other enzyme. **5**

(ii) Explain how enzymes improve the rates of reactions.

(iii) List TWO factors that can affect the activities of enzymes. Give an example where an enzyme might be affected by each factor.

(b) (i) In animal cells, energy production occurs at different sites. Name the site where each of the following processes occurs: **8**

1. glycolysis;

2. carboxylic acid cycle (Krebs cycle).

(ii) What are the relative differences in energy production associated with glucose forming either lactic acid or CO_2 and H_2O? Give numerical values.

(iii) Of what advantage is anaerobic metabolism in active muscle, even when oxygen is present?

(iv) 1. Assume the average energy requirement of a human is 9000 kJ/day. The energy gained by ATP $\rightarrow$ ADP + P is about 30 kJ/mole, and the molecular weight of ATP is 504 g.

What mass of ATP (in grams) is used per day?

2. Based on your calculation in part 1, is ATP an appropriate form of stored energy compared to fat at 39 kJ/g? Explain.

Question 13 continues on page 28

QUESTION 13. (Continued) **Marks**

(c) (i) Use the overall equations of photosynthesis and respiration to show the relationship between these TWO processes. **2**

(ii) Based on your understanding of this relationship, what external source of energy ultimately results in the ability to generate ATP during respiration?

(d) Nitrogen fixation is immensely important to agricultural productivity as it can limit plant growth. **2**

(i) What type of organism assists plants in nitrogen fixation?

(ii) What is the most common form of nitrogen taken up by plant roots?

(e) Our knowledge of the mineral requirements of plants is based on experiments with plants grown in mineral solutions (hydroponics). A species of plant is given CO_2, H_2O, and N_2, plus sources of K, Ca, P, S, and Fe, but still shows symptoms of deficiency. **7**

(i) Predict THREE additional nutrients that the plant may require.

(ii) Design an investigation to test your prediction, using appropriate scientific method.

(iii) List a different function linked to each of the following elements in the biochemistry of plants:

1. nitrogen;

2. phosphorus.

(f) What are TWO differences in the chemical structure between DNA and RNA molecules? **1**

QUESTION 14. Photography **Marks**

(a) An object 30 mm high is placed 100 mm in front of a simple camera lens of focal length 40 mm. **3**

(i) Draw a ray diagram to scale, showing the production of the image.

(ii) Describe the image produced by the lens in part (i).

(b) Zoom lenses are very popular in photography. What are TWO advantages of zoom lenses over lenses with fixed focal length? **1**

(c) Describe TWO design solutions used in manufacturing lenses that increase the brightness of the image produced. **2**

(d) Describe TWO differences between the processing of black and white negatives and the processing of black and white transparencies. **2**

(e) An exposure meter is used to determine a suitable exposure for a photograph. The table shows a range of possible camera settings for this photograph. **4**

	A	*B*	*C*	*D*	*E*	*F*
P	5·6	8	11	16	22	32
Q	250	125	60	30	15	8

(i) What exposure factors are represented by *P* and *Q*?

(ii) Under what circumstances would a photographer use:

1. setting *A*?

2. setting *F*?

(iii) While using exposure setting *F*, what technique may be used to improve image quality?

(f) What is ONE application of: **2**

(i) infra-red photography?

(ii) ultraviolet photography?

Question 14 continues on page 30

QUESTION 14. (Continued) **Marks**

(g) A film is labelled 'ASA400/DIN27'. **2**

(i) What feature of the film is described by this code?

(ii) What is ONE suitable application of film with this label?

(h) A student wishes to take photographs in very poor light conditions. She is using a camera with a focal-plane shutter attached to a simple flash gun. **3**

(i) The camera's instructions recommend a shutter speed of 1/50 second for this photograph. What is the reason for this recommendation?

(ii) What TWO factors will determine the choice of lens aperture for this photograph?

(i) Achromatic lenses are designed to reduce particular problems with image formation. **3**

(i) What lens problems are improved by achromatic lenses?

(ii) Explain how these lenses reduce the problem.

(j) (i) Describe the chemical change that takes place when exposed monochrome film is placed in film developer. **3**

(ii) How does temperature affect the development of film?

QUESTION 15. Physics in Medicine **Marks**

(a) Some students saw a cathode ray oscilloscope (CRO) in a school laboratory. They asked their teacher to show them a heartbeat on the screen. **3**

(i) List TWO additional pieces of equipment the teacher would need, to produce an ECG trace on the screen.

(ii) State the property of biological tissues that allow machines to make ECG and EEG records.

(b) Thermocouples and clinical thermometers can be used to monitor body temperature. Briefly describe **3**

(i) TWO advantages of using thermocouples;

(ii) ONE disadvantage of using thermocouples.

(c) The blood pressure of a patient is recorded as 115/80. Describe how such a measurement is made, and explain what each number represents. **4**

(d) (i) Name ONE medical instrument that uses ultrasound. **4**

(ii) Describe how the ultrasonic waves from the named instrument provide useful information.

(iii) State ONE advantage of using this instrument, instead of an alternative medical technique.

(e) ^{60}Co decays by β-emission into ^{60}Ni, that immediately emits two γ-rays. These γ-rays are commonly used in cancer treatment. The half-life of ^{60}Co is 5·27 years and the γ-rays have a quality factor of 0·7. **6**

(i) Determine the activity of 0·014 moles of ^{60}Co.

A 68 kg patient undergoing radiotherapy receives a total of 74 mJ of energy from the two γ-rays each second. Calculate:

(ii) the dose received each second;

(iii) the total dose received after two hours;

(iv) the dose equivalent.

Question 15 continues on page 32

QUESTION 15. (Continued) **Marks**

(f) Optical fibres are now integral components of many medical diagnostic instruments. **3**

(i) Briefly explain how light is transmitted along an optical fibre.

(ii) Give ONE application of optical fibre technology in medicine.

(g) Laser light can be used in medicine to cut, weld, and illuminate. Describe the properties of laser light that allow it to be used in these ways. **2**

QUESTION 16. Space Science **Marks**

(a) Konstantin Tsiolkovsky was a visionary pioneer of rocketry. For each of the following, explain TWO ways in which Tsiolkovsky's work pre-empted: **4**

(i) modern rocket design;

(ii) modern spacecraft cabin design.

(b) Dr Robert Goddard was an American scientist who conducted numerous rocketry experiments. With particular reference to Goddard's aims and conclusions, describe ONE of these experiments. **3**

(c) A common misconception about rockets is that they work only in the atmosphere because the exhaust gases push against the air to give forward thrust. Explain how rockets actually work, in terms of the physical principles involved. **3**

(d) Model rockets that can be purchased from hobby shops make use of solid fuel engines. The main engines of NASA's space shuttle burn liquids. **3**

(i) Describe how solid and liquid propellants are similar.

(ii) Give TWO reasons why most large rockets use liquid propellants.

(e) Collision with space debris is one problem facing high-altitude spacecraft. This problem should be less significant for spacecraft in low-altitude orbits. Explain this, using gravitational theory. **3**

(f) Outline TWO important discoveries made during recent explorations of the *outer planets*. Explain how these discoveries have influenced our understanding of the solar system. **4**

(g) If an unprotected human body were placed in space: **5**

- there would be no oxygen to breathe;
- it would be struck by particles with temperatures of 3000°C;
- water in tissues throughout the body would boil;
- about 2 kg of water would boil away from the lungs;
- death would occur in about three minutes.

Describe the life-support systems developed to protect astronauts from these biological problems.

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DATA SHEET

Values of several numerical constants

Avogadro's constant, N_A	$6{\cdot}022 \times 10^{23}$ mol^{-1}
Elementary charge, e	$1{\cdot}602 \times 10^{-19}$ 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	$9{\cdot}109 \times 10^{-31}$ kg
Mass of neutron, m_n	$1{\cdot}675 \times 10^{-27}$ kg
Mass of proton, m_p	$1{\cdot}673 \times 10^{-27}$ 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	$3{\cdot}00 \times 10^8$ m s^{-1}
Coulomb's constant, k	$9{\cdot}0 \times 10^9$ N m^2 C^2
Permeability constant, μ_0	$4\pi \times 10^{-7}$ N A^{-2}
Universal gravitation constant, G	$6{\cdot}7 \times 10^{-11}$ N m^2 kg^{-2}
Mass of Earth	$6{\cdot}0 \times 10^{24}$ kg
Radius of Earth	6378 km
Planck's constant, h	$6{\cdot}626 \times 10^{-34}$ J s
Density of water	$1{\cdot}00 \times 10^3$ kg m^{-3}
Specific heat capacity of water	$4{\cdot}18 \times 10^3$ J kg^{-1} K^{-1}
Speed of sound in air	340 m s^{-1}

Some Standard Potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2·94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2·91 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
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1·68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1·18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0·83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0·76 V
$S(s) + 2e^-$	$\rightleftharpoons$	S^{2-}	–0·57 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0·44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0·24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0·14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0·13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0·00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0·16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0·34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0·40 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^-	1·08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1·10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1·23 V
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	1·36 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^-	2·89 V

Alyward and Findlay, *SI Chemical Data* (3rd Edition) is the principal source of chemical data for this examination paper. Some data may have been modified for examination purposes.

PERIODIC TABLE

KEY

Atomic Number — Symbol of element

Atomic Mass — Name of element

																	2 He 4·003 Helium
3 Li 6·941 Lithium	4 Be 9·012 Beryllium											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 32·07 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 47·88 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 58·69 Nickel	29 Cu 63·55 Copper	30 Zn 65·39 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

This sheet should be REMOVED for your convenience.