BOARD OF STUDIES
NEW SOUTH WALES

**HIGHER SCHOOL CERTIFICATE EXAMINATION**

# 1998

# 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.

  The answer to Elective 9 must include page 49 from the Question 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 Pages

QUESTION 1. Flowering Plants and Mammals ..... 3–5

QUESTION 2. Reproduction and Genetics ..... 6–7

QUESTION 3. Micro-organisms and Disease ..... 8–9

QUESTION 4. Coordination and Control ..... 10–11

GROUP 2—CHEMISTRY ELECTIVES

QUESTION 5. Energy ..... 12–15

QUESTION 6. Atomic Structure and the Periodic Table ..... 16–18

QUESTION 7. Carbon Chemistry ..... 19–21

GROUP 3—GEOLOGY ELECTIVES

QUESTION 8. Regional Geology ..... 22–23

QUESTION 9. Mountains ..... 24–25

GROUP 4—PHYSICS ELECTIVES

QUESTION 10. Electromagnetism ..... 26–29

QUESTION 11. Oscillations and Waves ..... 30–33

QUESTION 12. Light ..... 34–35

GROUP 5—INTERDISCIPLINARY ELECTIVES

QUESTION 13. Biochemistry ..... 36–38

QUESTION 14. Photography ..... 39–40

QUESTION 15. Physics in Medicine ..... 41–43

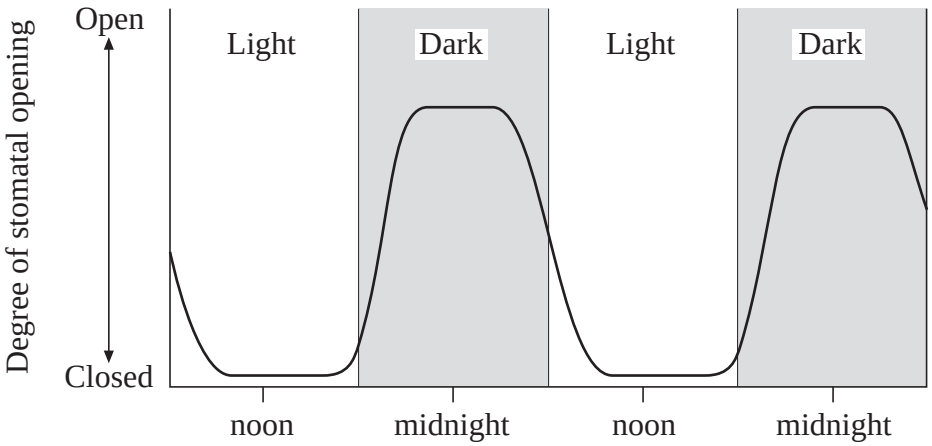
QUESTION 16. Space Science ..... 44–45

## GROUP 1—BIOLOGY ELECTIVES

**Marks**

### QUESTION 1. Flowering Plants and Mammals

(a) The Crassulaceae plant family has an unusual stomatal cycle as illustrated in the graph. **4**




*W K Purves, G H Orians and HC Heller 'Life: The Science of Biology, 4th ed Sinauer Assoc, 1995, p 698*

(i) Describe how the stomatal opening cycle of most plants would be different to that of the crassulaceans.

(ii) Draw a labelled diagram of a crassulacean stomate as it would appear at noon.

(iii) Based on the stomatal cycle, describe the environment you would expect crassulaceans to inhabit. Give reasons for your answer.

(b) Phloem and xylem are the two major conducting pathways of angiosperms. **4**

(i) Explain the effect metabolic inhibitors (that limit ATP production) would have upon conduction through:

1. phloem;
2. xylem.

(ii) Describe the difference in the composition of the material transpired compared to that translocated.

(iii) Draw a labelled diagram showing the characteristic features of tissue associated with carbohydrate transport within angiosperms.

**Question 1 continues on page 4**

QUESTION 1. (Continued) **Marks**

(c) For ONE environmental stimulus that involves a hormonal response in plants: **2**

(i) name the stimulus and name the hormone involved in the response;

(ii) describe the response of the plant to the hormone named in part (c) (i).

(d) Digestion and absorption are essential for the provision of substrates for metabolism in mammals. **4**

(i) Name the organ where the greatest absorption of digestive products occurs.

(ii) What mechanical and structural characteristics aid absorption in the organ named in part (d) (i)?

(iii) Name a substance that is absorbed into the lacteal.

(iv) Suggest a reason for absorption via the lymphatic system of the substance named in part (d) (iii).

(e) Blood transports oxygen and carbon dioxide between respiratory surfaces and the tissues of mammals. **3**

(i) When blood enters active skeletal muscle, the level of haemoglobin–oxygen saturation decreases. Explain why this decrease in level occurs and give its functional significance.

(ii) List TWO ways in which carbon dioxide is transported in the blood.

(f) (i) Draw a labelled diagram of a reflex arc of a mammal. **3**

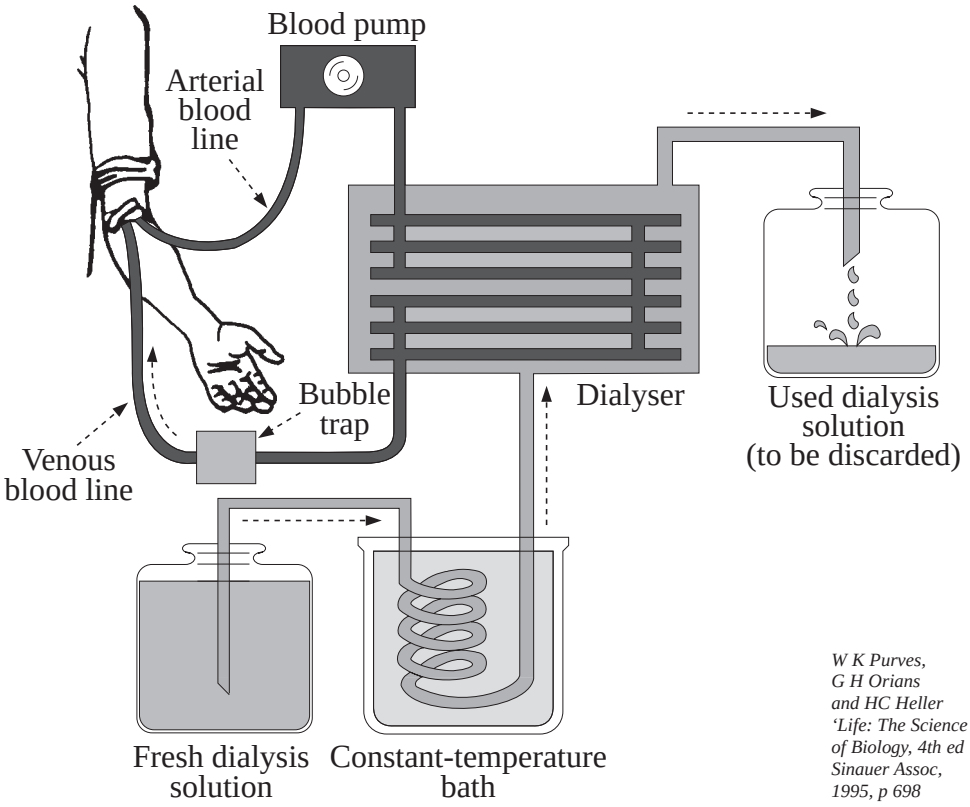
(ii) The brain plays a role in reflexes. Describe this role.

**Question 1 continues on page 5**

QUESTION 1. (Continued) **Marks**

(g) A renal dialysis unit is illustrated in the diagram. These units are used to remove wastes from the blood of people suffering renal problems. In a dialysis unit the blood of a patient is brought into close contact with a dialysis fluid. **5**

The diffusion of substances between blood and the fresh dialysis solution depends on the concentration gradients between the two solutions.




*W K Purves, G H Orians and HC Heller 'Life: The Science of Biology, 4th ed Sinauer Assoc, 1995, p 698*

(i) Describe the relative concentration in the fresh dialysis solution compared to blood entering the dialyser of:

1. urea;

2. glucose.

(ii) With the dialyser, the exchange of materials is passive and requires no energy. The kidney uses a large amount of energy to perform a similar function. Give a reason for the different energy requirements.

(iii) Describe the role of the renal system in homeostasis.

**End of question**

**QUESTION 2. Reproduction and Genetics** **Marks**

(a) Reproduction in organisms occurs by both asexual and sexual means. **5**

(i) Name THREE distinct forms of asexual reproduction and, for each, describe the process involved.

(ii) Since asexual reproduction allows successful individuals to produce identical clones, sexual reproduction offers no additional advantages to the survival of a species. Comment on this statement with reference to evolutionary theory.

(b) Normal parents have produced an offspring with an XXY complement of sex chromosomes as a result of the fusion of two gametes. **2**

List all possible genotypes (sex chromosomes only) of gametes produced by the parents of the individual XXY:

(i) mother;

(ii) father.

(c) Describe the role of restriction nuclease enzymes in recombinant DNA technology. **2**

(d) Pea plants have seven chromosomal pairs. Gregor Mendel studied seven characters of pea plants. Genes controlling pod shape and plant height (two characters studied) occur on the same chromosomes. **3**

(i) How could the position of the genes have complicated Mendel's experiment on the inheritance of pod shape and plant height?

(ii) What chromosomal behaviour could have minimised the impact of this complication? Explain your answer.

(e) A new treatment for infertility is Gamete Intra-Fallopian Transfer or the GIFT procedure. This can be used by about 65% of infertile couples. The procedure involves multiple ovulation techniques and laparoscopy with both the egg and sperm introduced into the Fallopian tube. **2**

Explain ONE difference between GIFT and IVF (in vitro fertilisation) techniques.

(f) (i) For BOTH a bacterium and a self-pollinating plant, compare the genotype of the offspring to the parent organism. **2**

(ii) State an advantage of reproduction by cross-pollination over self-pollination.

**Question 2 continues on page 7**

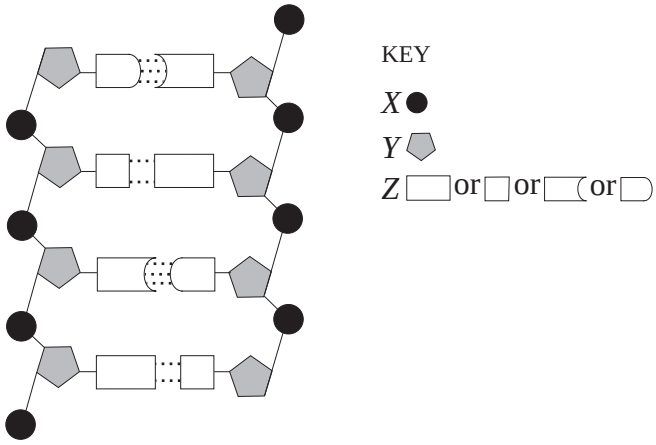
QUESTION 2. (Continued) **Marks**

(g) During adolescence an individual suffered a mutation in a liver cell. The mutation increased the rate of cell division and resulted in the progeny of this cell becoming a major portion of the liver. The mutation had no effect on the health of the individual. **2**

(i) What type of cell division is involved in the production of new liver cells?

(ii) Explain what effect this mutation in the liver would have on any children born to this individual.

(h) A diagram of a nucleic acid molecule is shown. **3**




(i) Name components *X* and *Y*.

(ii) Explain the significance of the various forms of component *Z*.

(i) Viruses cause diseases the symptoms of which range from mild to life threatening. **2**

(i) Describe how viruses can multiply in the human host.

(ii) A developing embryo that contracts a viral disease, for example the Rubella virus disease, may develop abnormally (eg deafness, heart defects, cataracts). The same virus may produce no effect in adults. Explain why a virus may have a much greater effect on the embryo.

(j) (i) What are the sites of fertilisation in: **2**

1. angiosperms?

2. mammals?

(ii) What cellular events follow fertilisation?

**End of question**

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

(a) To answer the following questions, choose a micro-organism that causes a disease in an animal. **4**

(i) Name the micro-organism and the disease that it causes.

(ii) Describe methods used to control the micro-organism at different stages of its life cycle.

(iii) Outline the mode of transmission of the micro-organism to the animal host.

(b) Yoghurt is made by cultivating two different bacteria (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*). **4**

(i) Describe the materials and methods that you would employ to obtain a pure culture of *Streptococcus thermophilus*.

(ii) Describe the techniques that could be applied to identify each of the two species.

(iii) Discuss the economic importance of micro-organisms. Provide an example in your answer.

(c) In the pre-antibiotic era, human patients received antibodies for diphtheria in the form of serum from animals. Serum could be produced by exposure of the animals to the bacterium *Corynebacterium diphtheriae* or a toxin of the bacterium. **3**

(i) Explain why serum from horses exposed to either the toxin or the bacterium might be effective in combating diphtheria in humans.

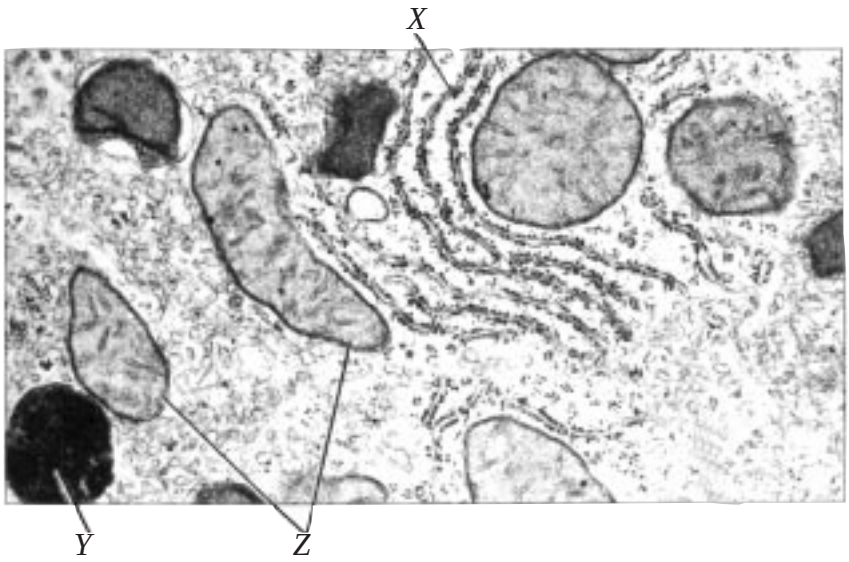
(ii) Why would an immune response against the bacterium be more effective in the long term?

(iii) What problems associated with the immune system could occur with the introduction of animal serum into the human body?

**Question 3 continues on page 9**

QUESTION 3. (Continued) **Marks**

(d) Study the electron micrograph (EM). **5**




*A J Vander, J H Sherman, D S Luciano, Human Physiologoy, 5th ed, McGraw-Hill 1990, p 47*

(i) What structures are labelled *X*, *Y* and *Z*? Describe a function for each structure identified.

(ii) From the features displayed in the EM, classify the organism as either procaryotic or eucaryotic, and give the reasons for your classification.

(e) The immune system is our defence against foreign organisms, chemicals and abnormal cells. **6**

(i) Which lymphocytes are primarily associated with cell-mediated immune responses, and does this involve antigens free in tissue fluids? Explain your answer.

(ii) Describe how antibodies can result in the destruction of micro-organisms.

(iii) An initial immunological response may involve inflammation. Describe the immunological events involved in inflammation.

(f) The discovery of penicillin in 1928, and other antibiotics thereafter, revolutionised medical practices, but their effectiveness may be short lived. **3**

(i) Explain why antibiotics might not provide protection against common pathogens in the future.

(ii) Why are viruses not treatable with conventional antibiotics?

**End of question**

**QUESTION 4. Coordination and Control** **Marks**

(a) The pituitary gland is often referred to as the master endocrine gland of the body due to its central role in coordinating endocrine function. Choose a pituitary hormone that has a stimulatory or inhibitory effect on a second hormone within the body. **3**

(i) Name the pituitary hormone and the second hormone.

(ii) Name the organ or tissue that produces the second hormone.

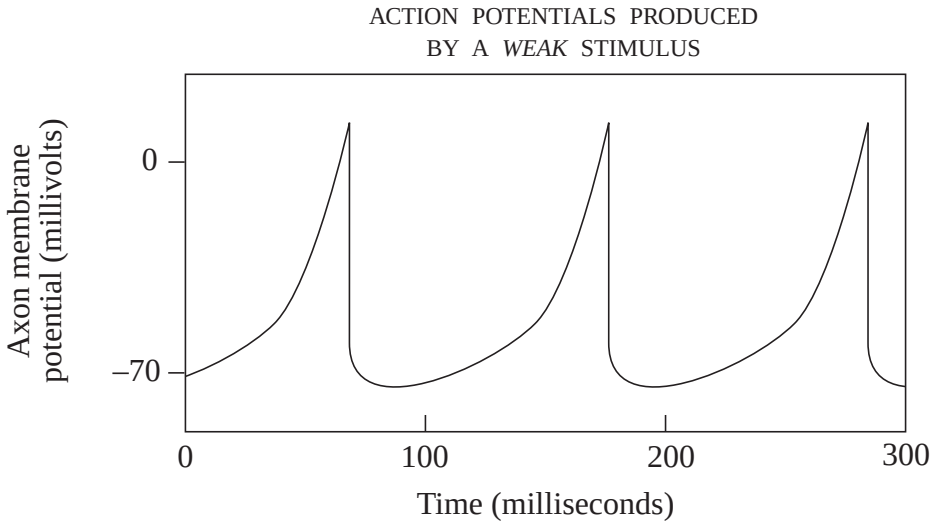
(iii) Describe a site of action and the physiological processes stimulated or inhibited by the named second hormone.

(b) Choose a hormone that is controlled by the autonomic nervous system and is also involved in homeostatic regulation. **3**

(i) Name the hormone, its site of production and target tissue(s).

(ii) Describe the interaction between the named hormone and the autonomic nervous system that results in homeostatic regulation.

(c) Nerves can provide rapid communication between control centres and effector organs and tissues. This communication involves action potentials as shown below. **4**




(i) Action potentials involve depolarisation and repolarisation of membranes. Describe changes associated with membrane depolarisation.

(ii) Describe changes in action potentials produced by a *strong* stimulus.

(iii) How does myelination of nerve axons increase conduction velocity of nerve impulses?

**Question 4 continues on page 11**

QUESTION 4. (Continued) **Marks**

(d) (i) Draw a nerve cell synapsing with two other nerve cells. Label the components of ONE of the nerve cells and indicate the direction of the nerve impulse. **4**

(ii) Acetylcholinesterase (that breaks down the neurotransmitter acetylcholine) is normally present at synapses. Malathion, an agricultural insecticide, can inhibit acetylcholinesterase. Explain why inhibition of the enzyme may lead to a malfunction of the nervous system.

(e) Which part(s) of the nervous system can control: **2**

(i) increases in heart rate?

(ii) increases in gut movement?

(iii) contraction of skeletal muscle?

(iv) the process involved in interpreting information?

(f) Genetic *dwarfism* can be accomplished in a number of plants by the single mutation of a gene. **2**

(i) What plant growth substance does the mutation most likely affect?

(ii) How can this dwarfism be reversed in a plant?

(g) The thyroid hormone thyroxin consists of two molecules of the amino acid tyrosine and four atoms of iodine. Thyroxin promotes synthesis of new adrenaline receptors on target cells. **2**

(i) What would be the effect of dietary iodine deficiency on the adrenaline response? Explain.

(ii) If both thyroid hormone and adrenaline were injected simultaneously, would adrenaline action be improved? Explain.

(h) A species of short-day plant flowers when the photoperiod (light period) is less than 15·7 hours in a normal 24 hour day/night cycle. **5**

(i) Describe an experiment that could be conducted to test the above statement.

(ii) How would you modify your experiment to test the hypothesis that leaves in this plant species act as receptors for this response to photoperiod?

**End of question**

## GROUP 2—CHEMISTRY ELECTIVES

**Marks**

**QUESTION 5. Energy**

(a) (i) When 3·19 g solid sodium hydroxide (NaOH) dissolves in 80·0 g water in a polystyrene calorimeter the temperature increases from 22·5°C to 43·2°C. **9**

1. Calculate $\Delta H$ (in kJ mol$^{-1}$) for the dissolution of sodium hydroxide in water. Assume that the specific heat of the solution is the same as that for pure water.

2. The latent heat of fusion of sodium hydroxide is 6·4 kJ mol$^{-1}$. Explain why there is such a large net difference in the energy involved in melting and dissolving sodium hydroxide.

(ii) The standard enthalpy of formation for three compounds is given below.

$\Delta H_f^\circ$ ($H_2O(l)$) = –286 kJ mol$^{-1}$

$\Delta H_f^\circ$ ($CO_2(g)$) = –394 kJ mol$^{-1}$

$\Delta H_f^\circ$ ($C_{57}H_{110}O_6(s)$) = –37 760 kJ mol$^{-1}$

1. Determine the enthalpy of combustion for the fat tristearin, $C_{57}H_{110}O_6(s)$, to produce carbon dioxide and liquid water.

2. Calculate the energy released through the combustion of 1 g of tristearin.

3. A carbohydrate, glucose, $C_6H_{12}O_6$, burns in air to form carbon dioxide and liquid water. The enthalpy for the combustion of solid glucose is –2803 kJ mol$^{-1}$. Compare the energy available for 1 g of glucose with that of 1 g of tristearin.

(iii) The enthalpy of atomisation for methane is 1660 kJ mol$^{-1}$.

1. Write a chemical equation to describe the atomisation of methane. Include the energy term in your equation.

2. Use the value for the atomisation of methane to calculate the bond energy for one mole of carbon–hydrogen bonds.

3. Explain why bond energies are given as positive values.

4. Would the same bond energy be calculated for one mole of carbon–hydrogen bonds if the calculations were based on a different compound to methane? Clearly explain your answer.

**Question 5 continues on page 13**

QUESTION 5. (Continued) **Marks**

(b) The rechargeable nickel–cadmium cell has a voltage of 1·3 V and involves two reversible reactions: **4**

$$Cd(OH)_2 + 2e^- \rightleftharpoons Cd + 2OH^- \qquad E° = -0{\cdot}81\ V$$

$$NiO_2 + 2H_2O + 2e^- \rightleftharpoons Ni(OH)_2 + 2OH^- \qquad E° = +0{\cdot}49\ V$$

(i) Write the balanced ionic equation for the nickel–cadmium cell as it is being recharged.

(ii) What is the minimum voltage required in this recharging process?

(iii) While the nickel–cadmium cell is discharging, the cadmium electrode has a particular charge.

1. What is the sign of the charge on the cadmium electrode? Explain how the charge is produced.

2. Give the chemical name for the discharging reaction.

(iv) When the nickel–cadmium cell is recharging, the cadmium electrode has a different sign to that in part (b) (iii).

1. Explain why the recharging process results in a change of sign of the charge at the cadmium electrode.

2. The recharging process has a particular chemical name associated with it. Give the chemical name for the recharging process.

**Question 5 continues on page 14**

QUESTION 5. (Continued) **Marks**

(c) Fuels are described in terms of their properties: **5**

- heat of combustion
- ignition temperature
- vaporisation temperature
- volatility
- combustion products and environmental effects
- safety aspects (flash point, flammability).

(i) Describe each of the above properties as it relates to fuels.

(ii) The table shows the energy released through the complete reaction of some fuels with oxygen.

| Fuel | kJ $mol^{-1}$ | kJ $g^{-1}$ |
|---|---|---|
| $H_2(g)$ | –286 | — |
| $CH_4(g)$ | –890 | –55·6 |
| $C_3H_8(g)$ | –2220 | –50·3 |
| $C_8H_{18}(l)$ | –5470 | — |
| $CH_3OH(l)$ | –726 | –22·7 |

1. Determine the energy released per gram for each of $H_2$ and $C_8H_{18}$.

2. Which fuel listed in the table would be the most efficient? Give reasons for your choice.

**Question 5 continues on page 15**

QUESTION 5. (Continued) **Marks**

(d) Coal and coke are commonly used as industrial fuels. However, the use of these two fuels can cause environmental problems. **3**

(i) Describe TWO of the environmental problems associated with the combustion of coal and/or coke.

(ii) How does industry overcome BOTH problems described in part (d) (i)?

(iii) List TWO industries that use coal and/or coke as their main fuel source.

(e) Alkanols can be used as fuels. However, as the carbon number increases, the flame becomes more luminous or sooty. The lower carbon number alkanols combust with a blue flame. **4**

(i) Write the chemical equation for the combustion of ethanol to produce a blue flame.

(ii) Write the chemical equation for the combustion of butanol to produce a more luminous (sooty) flame.

(iii) Which flame colour produces the most heat or energy? Explain.

(iv) What are TWO problems associated with the combustion of butanol described above, and how could these two problems be overcome?

(v) Which of the two alkanols would be expected to have the higher ignition temperature? Explain your choice.

**End of question**

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

(a) Ernest Rutherford proposed a solar system model for the atom. In his model, negative electrons orbit a small positively charged nucleus in the same way that the planets orbit the Sun. Rutherford identified positively charged subatomic particles, protons, in the nucleus of the atom. He thought that the nucleus of atoms should also contain another type of subatomic particle. He was not able to find this particle and it was not discovered for many years. **2**

(i) Rutherford hypothesised the existence of a subatomic particle. Name this subatomic particle.

(ii) Who was responsible for the eventual discovery of this subatomic particle?

(iii) The invention of which instrument led to the discovery of this subatomic particle?

(iv) Which property of this subatomic particle made it difficult to find?

(b) Sodium nitride, $Na_3N$, is an ionic compound that may be formed when sodium metal is heated in nitrogen gas. **3**

(i) Write a chemical equation to describe the formation of sodium nitride.

(ii) To which blocks of the periodic table do sodium and nitrogen belong?

(iii) Give the electronic configurations for the sodium ion and nitride ion, including shells and subshells.

(iv) Explain why bismuth does not form a similar compound with sodium.

(c) Describe the contribution of each of the following scientists to the development of our understanding of the behaviour of electrons in atoms. **3**

(i) Thomson

(ii) Bohr

(iii) Heisenberg

**Question 6 continues on page 17**

QUESTION 6. (Continued) **Marks**

(d) (i) Shells, subshells and orbitals are concepts that can be used to describe the electronic configuration of an element. **8**

1. Describe the difference between these three concepts, using the electron configuration of the element oxygen to illustrate your answer.

2. Give a pictorial representation of an *s*-subshell and a *p*-subshell.

(ii) Give the electronic configuration in shells and subshells of calcium as the:

1. atom

2. ion.

(iii) Using information in part (d) (ii), explain fully why calcium will not readily form compounds containing $Ca^{3+}$ or $Ca^{+}$.

(iv) Which groups of elements in the periodic table form the:

1. *s*-block?

2. *p*-block?

3. *d*-block?

(v) To which block of elements do the lanthanides and actinides belong?

(e) The modern periodic table is based on the ideas put forward by Dmitri Mendeleev in 1869. **3**

(i) How is the periodic law proposed by Mendeleev different to that of the modern periodic law?

(ii) Many elements were not known in Mendeleev's day. However, he was able to predict the existence of a number of these unknown elements, such as germanium.

1. On what basis did Mendeleev leave a 'gap' for germanium?

2. How was Mendeleev able to predict closely the properties of germanium?

**Question 6 continues on page 18**

QUESTION 6. (Continued) **Marks**

(f) The Crookes tube is a specific example of a cathode ray tube. Radiation is produced in the Crookes tube when a high voltage is applied across the electrodes. **6**

(i) Why is this radiation known as cathode rays?

(ii) What is the charge of the cathode ray?

(iii) Describe how this charge was determined experimentally using the Crookes tube.

(iv) The cathode ray is known to consist of particles. Name these particles.

(v) Do different materials produce the same cathode rays? Give a reason for your answer.

(vi) What happens when a cathode ray hits a metal plate such as a Maltese cross, in a discharge tube?

(vii) Who, in 1897, used the cathode ray tube to determine the charge to mass ratio of the particles in cathode rays?

(viii) Fluorescence is produced as cathode rays pass through a partially evacuated Crookes' tube. Describe how the cathode rays cause the gas molecules in the Crookes tube to fluoresce.

**End of question**

**QUESTION 7. Carbon Chemistry** **Marks**

(a) Compound *A* is a hydrocarbon containing 85·7% carbon by mass, and with a molecular weight between 60 and 80. Compound *A* reacts with: **9**

- excess hot concentrated potassium permanganate to form two organic compounds, compound *B* and compound *C* (no further reactions are possible under these conditions);
- hydrogen bromide to produce compound *D* and compound *E;*
- hydrogen to form a single product, compound *F* under certain conditions;
- chlorine to form a single product, compound *G*.

(i) Calculate the empirical formula for compound *A*.

(ii) Determine the molecular formula for compound *A.*

(iii) 1. Write an equation for the reaction to form compounds *B* and *C.* Give the structural formulae for all organic species.

2. Compound *B* is of lower molecular mass than compound *C*. Name both compounds, *B* and *C*.

(iv) 1. Write an equation for the reaction to produce compounds *D* and *E.* Give the structural formulae for all organic species.

2. Label and name products *D* and *E*.

(v) Write an equation for the reaction between your compound *E* and dilute sodium hydroxide which is heated to produce a new compound, *H*. Give the structural formulae for all organic species. Name compound *H*.

(vi) Write an equation for the reaction between your compound *H* and compound *B.* Give the structural formulae for all organic species. Name the organic product.

(vii) Name compound *A.*

(viii) Describe the conditions necessary for hydrogen to react with compound *A* to produce compound *F*.

**Question 7 continues on page 20**

QUESTION 7. (Continued) **Marks**

(b) 1,2-ethanediol and 1,2,3-propanetriol are important alkanols. For each of these alkanols, give the: **2**

(i) structural formula;

(ii) major industrial use.

(c) The following are four reactions that involve alkanols. **8**

Reaction 1. 3-methyl-2-butanol is reacted with dilute $KMnO_4/H^+$ solution;

Reaction 2. ethanol is boiled with propanoic acid and some concentrated sulfuric acid;

Reaction 3. 3-methyl-2-butanol is reacted with concentrated sulfuric acid;

Reaction 4. propanoic acid is formed from its primary alkanol.

(i) For each of the reactions above, write the chemical equation, using structural formulae for all organic species.

(ii) Give the IUPAC name for all organic products of Reaction 1, Reaction 2 and Reaction 3.

(iii) Name the primary alkanol used in Reaction 4.

(iv) Name the type of reaction (eg addition) occurring in:

1. Reaction 1;

2. Reaction 2;

3. Reaction 3;

4. Reaction 4.

**Question 7 continues on page 21**

QUESTION 7. (Continued) **Marks**

(d) Esters are described as fruity, sweet-smelling substances. To produce an ester such as hexyl butanoate, two common organic procedures are used. These are reflux and then distillation. **6**

(i) Write the chemical equation for the reaction to produce the ester hexyl butanoate. Give the structural formula for this ester.

(ii) Name the catalyst used in this reaction.

(iii) Draw and fully label the working reflux apparatus used in making the ester above.

(iv) Explain why reflux is used to prepare the ester instead of heating the reactants in a beaker.

(v) Give the function of the distillation procedure in the production of the ester.

(vi) After distillation, the ester is boiled with sodium hydroxide.

1. Name the products formed.

2. Name this process.

3. Describe how the two products can be physically separated.

**End of question**

## 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.

Your answers for parts (b) to (f) must relate to the region named in part (a).

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

(b) In studying this elective you will have used a combination of field work, laboratory investigations, map study, and air photo study. Select TWO of these investigative techniques. Describe how each of the techniques selected increased your understanding of the region you have studied. Include specific examples in detail in your answer. **4**

(c) (i) Draw a map of the region you have studied. **4**

(ii) On your map, show the outcrops of TWO different igneous lithologies.

(iii) For each igneous lithology, explain the origin of its magma.

(d) (i) Draw a labelled east–west cross-section of the region you have studied. Show major topographic features as well as the most significant sub-surface structures. **6**

(ii) Select ONE significant subsurface structure from part (d) (i). This must not include examples used in part (c). Write an account of its formation. Refer to the lithologies involved and the tectonic processes that formed the structure.

(iii) State the ages of the lithologies involved and the age of the formation of the subsurface structure in part (d) (ii).

**Question 8 continues on page 23**

QUESTION 8. (Continued) **Marks**

(e) (i) Construct a stratigraphic column for the major rock units in an area in your region of study. You should indicate the names of major formations/groups, dominant lithologies including one that contains fossils, and geological ages. **7**

(ii) Draw a vertical line through your east–west cross-section in part (d) (i), where your stratigraphic column could be located.

(iii) Select ONE lithology from part (e) (i) which contains fossils. Name a fossil that occurs in that lithology, and state what it indicates about the depositional environment for that lithology.

(f) (i) Name TWO regions adjoining your region of study. **4**

(ii) For each adjoining region named in part (f) (i), state the age(s) of main rock units outcropping at the boundary with the region you have studied.

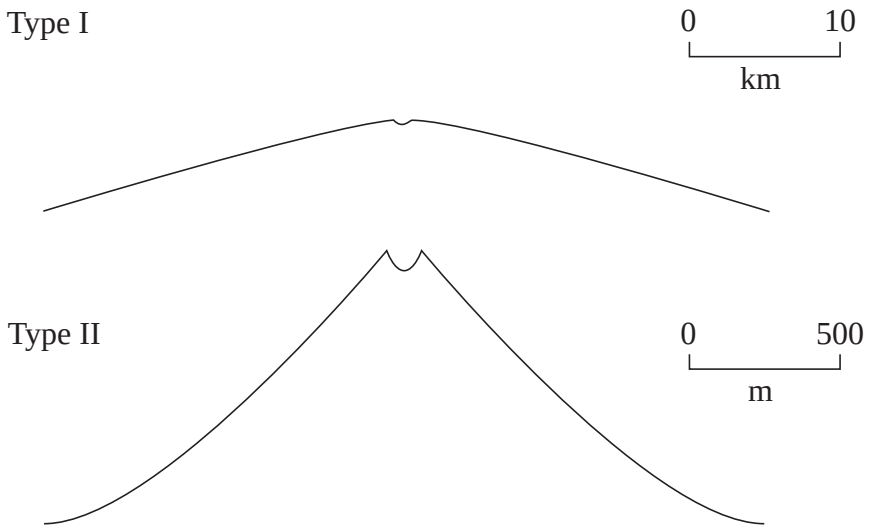
(iii) Briefly describe the tectonic relationship between the region you have studied for this elective and each adjoining region named in part (f) (i).

**End of question**

**QUESTION 9. Mountains** **Marks**

Use a SEPARATE Elective Answer Book and the World Map on page 49.

(a) The diagram shows the profiles of two different types of volcanic mountain. **12**




(i) Copy both profiles into your Elective Answer Book, and sketch in the internal structure of each volcano. Fully label your diagram.

(ii) For each of the two types of volcano shown above:

1. state the term that is used to describe the volcano;

2. describe a typical lava;

3. describe its eruption style.

Clearly indicate the type of volcano to which each part of your answer refers.

(iii) On the world map provided on page 49, and using the legend, show the locations of TWO:

1. Type I volcanoes;

2. Type II volcanoes;

and label each volcano with its name.

(iv) Throughout history, volcanic eruptions have produced a variety of social consequences. Referring to specific examples of Type I and/or Type II volcanic eruptions, state:

1. TWO beneficial consequences;

2. TWO harmful consequences.

**Question 9 continues on page 25**

QUESTION 9. (Continued) **Marks**

(b) (i) Mountaineers hiking through the Himalayas commonly find ammonite (marine invertebrate) fossils in black shale. **7**

Explain the occurrence of these marine fossils several thousand metres above sea level.

(ii) Modern fold mountains occur in two major tectonic environments. These are continent/continent convergence zones and ocean/continent convergence zones.

Draw a labelled cross-section through ONE of these two types of convergence zones, to illustrate the processes at work and the structures that form.

(iii) On the world map provided on page 49, and using the legend, indicate the area of a modern fold mountain range formed by:

- continent/continent convergence;
- ocean/continent convergence.

(c) Inhabitants of fold mountain areas are subject to a number of natural hazards. **3**

(i) Name TWO natural hazards in fold mountain areas.

(ii) Describe a specific example of ONE of the natural hazards named in part (c) (i) and its effect on people and/or their activities.

(d) Many older fold mountain ranges have granite exposed at the surface, yet granite forms at a depth of several kilometres. Describe the processes that lead to the exposure of granite. **2**

(e) On the world map provided on page 49 and using the legend, indicate the area of TWO major shield regions. **1**

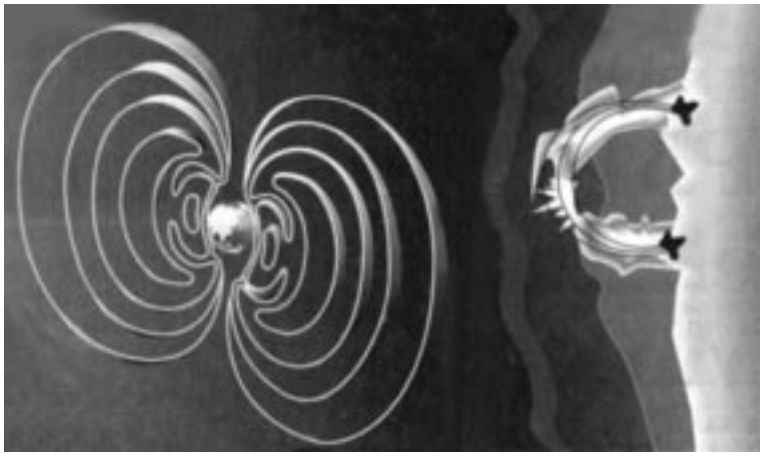
**End of question**

## GROUP 4—PHYSICS ELECTIVES

**Marks**

### QUESTION 10. Electromagnetism

(a) A recent article in the Sydney Morning Herald described how solar flares cause increased auroral activity. Auroras are bright lines in the sky that are caused by charged particles from solar flares interacting with the Earth's magnetic field as shown in the diagram below. **2**



EARTH'S MAGNETIC FIELD SOLAR FLARE



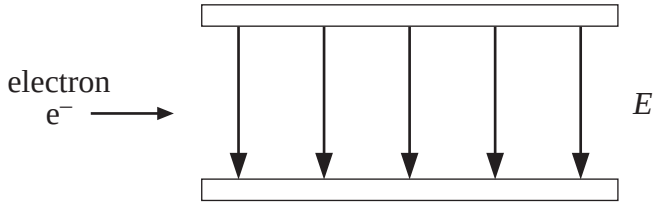
Would you be more likely to see auroras at the Earth's poles or at the equator? Explain your answer.

**Question 10 continues on page 27**

QUESTION 10. (Continued) **Marks**

(b) In a television tube, the beam of electrons that strike the screen is controlled by an electric field and a magnetic field. An electron is accelerated by a potential difference of 15·0 kV before it enters the electric field at right angles to the field. The magnitude of the electric field is 7·85 kV $m^{-1}$. **8**

(i) The diagram shows two parallel plates that produce the electric field *E*.




Copy the diagram into your Answer Book. On the diagram, show the path of an electron as it traverses the electric field.

(ii) The magnetic field is produced by two coils. Explain where the coils should be placed so that the electron travels parallel to the plates that produce the electric field.

(iii) What is the kinetic energy of the electron before it enters the electric field?

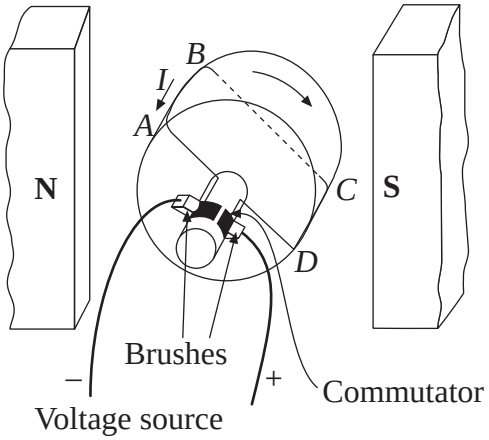
(iv) Calculate the velocity of the electron before it enters the electric field.

(v) The electron moves with constant velocity while under the influence of the combined fields. What magnetic flux density is required to keep the electron parallel to the electric field plates?

**Question 10 continues on page 28**

QUESTION 10. (Continued) **Marks**

(c) The diagram shows a simple dc motor. The letters *A*, *B*, *C*, *D* indicate the corners of the square current-carrying coil. **10**




(i) Explain how the dc motor works by explaining the function of:

1. the magnets;

2. the coil;

3. the commutator;

4. the brushes.

(ii) Why is the actual power developed by the motor always less than the theoretical power?

(iii) A dc motor like the one shown in the diagram, has a square current-carrying coil with 100 turns. The area of the coil is 4·2 $cm^2$. The coil carries a current of 4·5 A. The magnetic flux density of the motor is 1·3 T. The coil is inclined at an angle of 40° to the direction of the magnetic field.

Calculate:

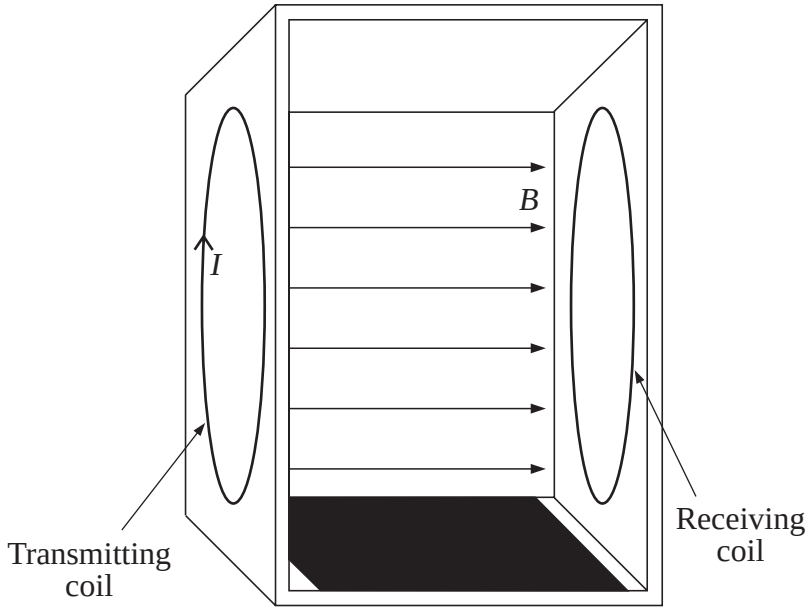
1. the force on side *AB*;

2. the torque on the coil.

**Question 10 continues on page 29**

QUESTION 10. (Continued) **Marks**

(d) The diagram shows an airport security gate. The magnetic field is produced by a varying current in the transmitting coil. **5**




(i) The magnetic flux density inside the receiving coil changes at a rate of $9{\cdot}45 \times 10^{-3}$ T $s^{-1}$. The area of the receiving coil is $0{\cdot}85$ $m^2$ and has 35 turns. Calculate the e.m.f. induced in the receiving coil.

(ii) At a particular time, the current in the transmitting coil flows in the direction shown in the diagram, and the magnetic flux density is increasing. How does the direction of the current in the receiving coil compare with the direction of the current in the transmitting coil at this time? Explain your answer.

(iii) The alarm sounds when a person carrying a metal object enters the security gate. The alarm is triggered by abnormal variation in the current flowing through the receiving coil. Explain how this abnormal variation is produced.

**End of question**

**QUESTION 11. Oscillations and Waves** **Marks**

(a) To throw a discus, a thrower spins in a circle as shown in the diagram. **3**

Two throwers use the same discus with a mass of 1·5 kg.
Thrower *A* has an arm length of 60 cm and completes 3 rotations in 5·2 seconds.
Thrower *B* has an arm length of 68 cm and completes 3 rotations in 4·9 seconds.

Which thrower gives the discus the greatest centripetal acceleration? Show working.

(b) At room temperature, the atoms in a solid gold bar vibrate at a frequency of $1{\cdot}00 \times 10^{13}$ Hz. Imagine that two atoms are connected by a spring. Assume that one of them vibrates in simple harmonic motion and the other is at rest. The amplitude of the vibration is $1{\cdot}20 \times 10^{-10}$ m. The mass of one gold atom is $3{\cdot}27 \times 10^{-25}$ kg. **4**

(i) Calculate the force constant of the spring.

(ii) What is the maximum magnitude of the force acting on the vibrating gold atom?

(iii) What is the maximum potential energy of the vibrating gold atom?

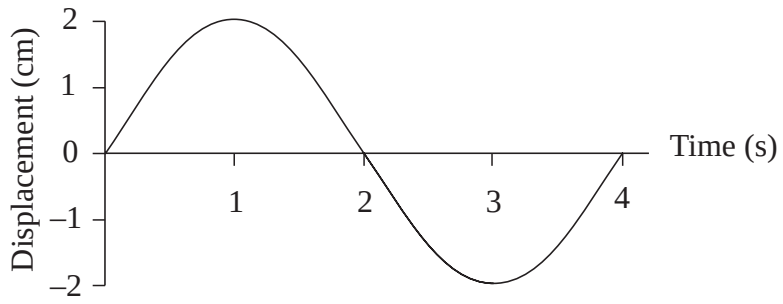
(iv) At what point in a vibration cycle does the gold atom experience the maximum potential energy? You may use a diagram to explain your answer.

**Question 11 continues on page 31**

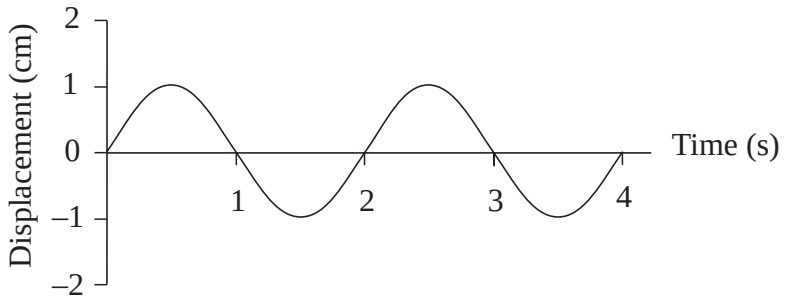
QUESTION 11. (Continued) **Marks**

(c) The diagrams show two simple sinusoidal waves with different amplitudes and frequencies. **4**

WAVE *A*




WAVE *B*




(i) What is the amplitude of Wave *A*?

(ii) Calculate the frequency of Wave *B*.

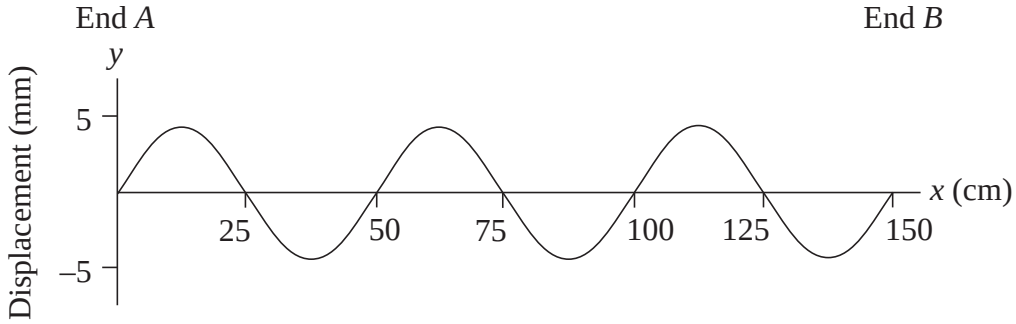
(iii) Describe the superposition principle as applied to waves.

(iv) Draw a fully labelled, scaled diagram of the complex wave formed by the superposition of these two simple waves.

**Question 11 continues on page 32**

QUESTION 11. (Continued) **Marks**

(d) The graph below shows the *x*–*y* displacement of a wave produced in a string instrument at the instant the string is plucked. The string is fixed at each end. **11**




(i) What type of wave is produced in the string at the instant it is plucked?

(ii) What is the wavelength of the wave?

(iii) The speed of this wave in the string is 1950 m $s^{-1}$. What is the frequency of the wave?

(iv) Draw a diagram of the fundamental mode of vibration of the string.

(v) A finger is placed a certain distance along the string. A standing wave is produced between the finger and end *B*. The standing wave has four nodes. Draw a diagram of this standing wave.

(vi) The wavelength of the standing wave in part (v) is 42 cm. What is the distance between the finger and end *B* in part (v)?

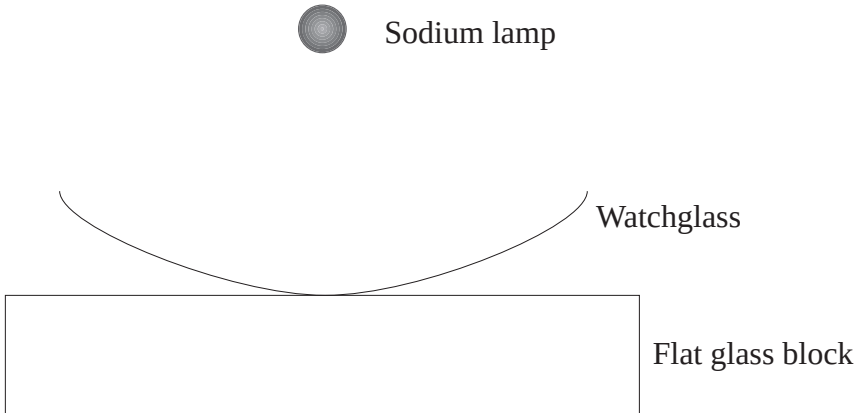
(vii) The standing wave in the string is an example of resonance. What are the requirements for resonance?

(viii) How is the energy of the standing wave in the string involved in the transmission of sound to a listener?

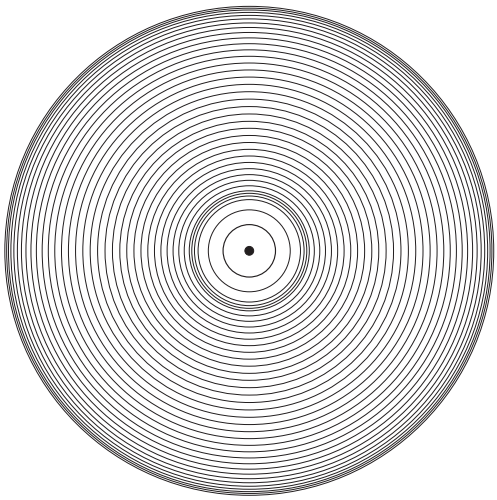
**Question 11 continues on page 33**

QUESTION 11. (Continued) **Marks**

(e) A pattern of dark concentric rings (Newton's Rings) is seen when rays from a sodium lamp shine through a watchglass placed on top of a flat glass block, as shown below. **3**




An observer viewing the apparatus from above sees the pattern of dark concentric rings shown below.



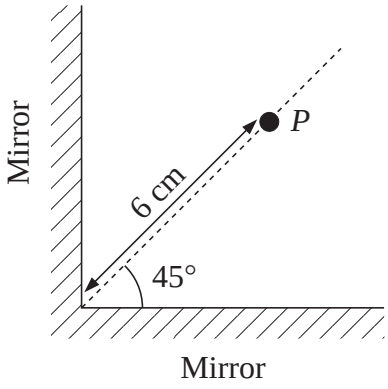
(i) What behaviour of light waves produces the pattern of concentric rings?

(ii) Explain how the pattern of concentric rings is produced.

**End of question**

**QUESTION 12. Light** **Marks**

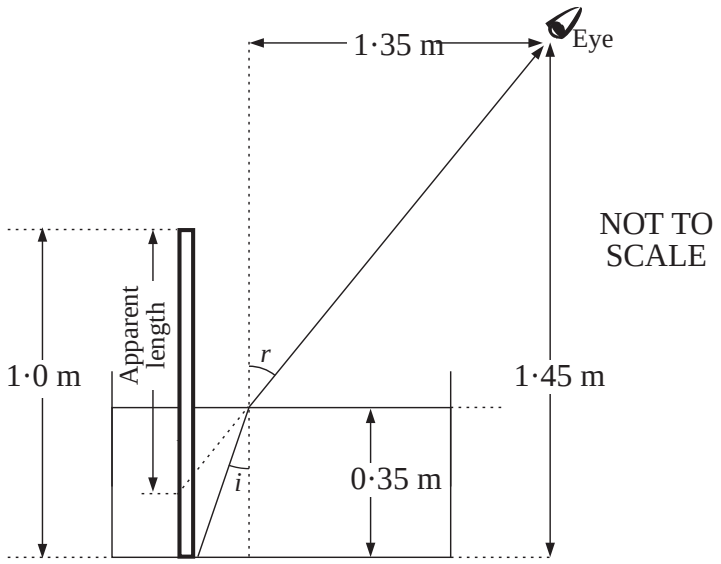
(a) Two plane mirrors are placed at right angles. A point object (*P*) is placed 6 cm along the bisector of the angle between the mirrors as shown in the diagram. **3**




Show the location of the THREE images of the object on a scaled ray diagram.

(b) (i) The velocity of yellow light in an organic liquid is $1{\cdot}92 \times 10^8$ m s$^{-1}$. The velocity of yellow light in air is $3{\cdot}0 \times 10^8$ m s$^{-1}$. What is the refractive index of the liquid? **6**

(ii) A 1·0 m ruler is placed into a container containing the liquid in part (b) (i). The depth of the liquid is 0·35 m. A student is standing a short distance from the container as shown in the diagram.




Determine:

1. the angle of refraction, *r*;
2. the angle of incidence, *i*;
3. the apparent length of the ruler.

**Question 12 continues on page 35**

QUESTION 12. (Continued) **Marks**

(c) A large spherical mirror is used as a street decoration. It produces a reflection of a 1·2 m high car. When the car is 3·2 m away from the decoration, the image is one-eighth of the size of the car. **5**

Determine the diameter of the decoration.

(d) (i) Describe TWO properties of electromagnetic waves. **7**

(ii) Arrange the following electromagnetic waves in order of increasing energy:

blue light, gamma rays, radio waves, ultraviolet light, yellow light, X-rays.

(iii) In an X-ray tube, electrons are accelerated by a potential difference of 50 kV. On striking a tungsten target, they produce X-ray photons.

1. Calculate the kinetic energy, in joules, of one electron just before it strikes the target.

2. Calculate the wavelength of the resultant X-rays, assuming that all the energy of the electrons is used to produce the X-rays.

(e) Explain why Einstein's relation and Huygens' principle, regarding the nature of light, are incompatible. **2**

(f) Polarising filters are often attached to cameras to reduce glare. This is particularly useful when photographs of water are taken. **2**

Explain why polarising filters are so useful under these conditions.

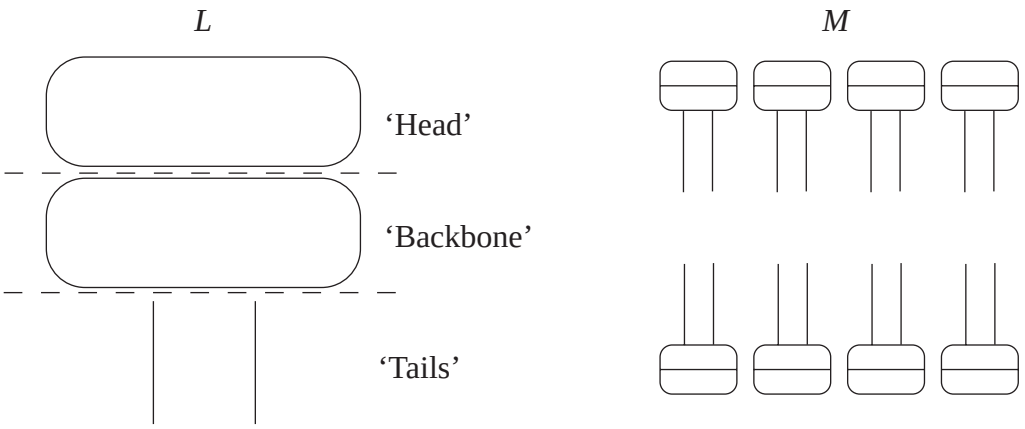
**End of question**

## GROUP 5—INTERDISCIPLINARY ELECTIVES

**Marks**

### QUESTION 13. Biochemistry

(a) A diagrammatic representation of a lipid *L* and a cell membrane *M* are shown. **3**




(i) For the lipid *L*, name the molecules that form:

1. the *backbone*;

2. the *tails*.

(ii) Explain the structure of the cell membrane, shown in *M*, based on the characteristic properties of lipids.

(iii) What distinguishing test can be used to determine the lipid-based nature of membranes?

(b) The nitrogen cycle consists of three stages: ammonification, nitrification and assimilation. **3**

(i) Name the type of organisms involved in nitrification.

(ii) What factors could affect the oxidation of $NH_3$ to $NO_3^-$?

(iii) Describe the major role played by nitrogen in metabolism in organisms.

**Question 13 continues on page 37**

QUESTION 13. (Continued) **Marks**

(c) Mutations can involve changes in nucleotide sequences of genes that alter the outcome of protein synthesis. **5**
One form of mutation involves single nucleotide substitution, for example;

| | |
|---|---|
| . . . T C C T G A G G A G . . . | Original |
| . . . T C C T G T G G A G . . . | Substitution |

A second form of mutation can involve either deletion or addition of a single nucleotide, for example;

| | |
|---|---|
| . . . T C C T G A A G G A G . . . | Addition |
| . . . T C C T G A G G A G . . . | Original |
| . . . T C C T G G G A G . . . | Deletion |

(i) Explain how:

1. substitution;

2. addition;

3. deletion;

can result in changes to protein structure.

(ii) Describe the mechanisms used by cells to translate the genetic code into protein molecules.

(d) Photosynthesis involves two reactions. **3**

(i) Write an equation for each reaction.

(ii) Based on these reactions, if a plant were provided with isotopically labelled water (ie $H_2O$ labelled with the isotope $^{18}O$), in what products of photosynthesis would the labelled oxygen appear?

(e) Every amino acid, except proline, has the same structure, in which only the *R* group attached to the $\alpha$–carbon varies. **3**

(i) Give the general structural formula for a typical amino acid in:

1. its non-ionic form;

2. a neutral aqueous solution.

(ii) What is the term used to describe amino acids in neutral aqueous solution?

(iii) What is chelation?

**Question 13 continues on page 38**

QUESTION 13. (Continued) **Marks**

(f) All cells of the body possess the biochemical pathways necessary to perform processes essential for life. Mammalian red blood cells lack organelles. **4**

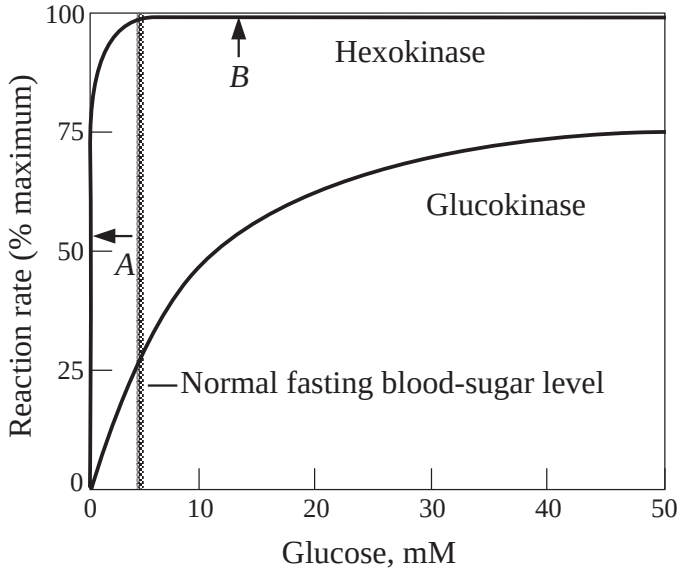
(i) How would red blood cells produce ATP?

(ii) Where in red blood cells would ATP production occur?

(iii) Write an equation that summarises red blood cell energy production.

(iv) Explain why this form of energy production would be required.

(g) The figure shows the relationship between substrate concentration (glucose) and reaction rate (% maximum) of two enzymes (hexokinase and glucokinase) under identical conditions. These two enzymes can catalyse the same reaction, converting glucose into glucose-6-phosphate. **4**




(i) These enzymes show different relationships between reaction rate and substrate concentration. Give a possible reason for this.

(ii) For hexokinase, explain the reason for the difference in reaction rate at points *A* and *B* as indicated on the figure.

(iii) Describe the relationship between reaction rate and substrate concentration if there were no enzymes to catalyse the reaction.

(iv) Describe an advantage of having more than one enzyme catalysing the same reaction.

**End of question**

**QUESTION 14. Photography** **Marks**

(a) A photographer wished to take photographs of two different scenes at the 1998 Nagano winter Olympics, using a good quality single-lens-reflex camera. **8**

*Scene 1:* A snow boarder descending the snow-covered sunlit slopes.

*Scene 2:* The snow boarder standing on the victory dais, indoors, to receive the medal in shadowy conditions against a dark background.

For each scene, state the photographer's choice of:

(i) film;

(ii) lens aperture;

(iii) exposure time;

(iv) one accessory;

and give reasons based on the physical principles involved to justify the photographer's choice.

(b) Describe with the aid of diagrams the difference between *depth of field* and *depth of focus*. **2**

(c) An amateur photographer used an exposure of f 4 at $\frac{1}{500}$ s. What lens aperture, together with a shutter speed of $\frac{1}{125}$ s, would give an equivalent exposure? **1**

(d) A well-focused image of a full Moon was cast on a white card using a convex lens of focal length 20 cm. The Moon is $3{\cdot}8 \times 10^8$ m from the Earth and has a diameter of $3{\cdot}5 \times 10^6$ m. **3**

(i) How far is the card from the lens?

(ii) What is the diameter of the image of the Moon?

(iii) What is the magnification of this image?

(e) Photography is a useful tool in the study of life sciences. **3**

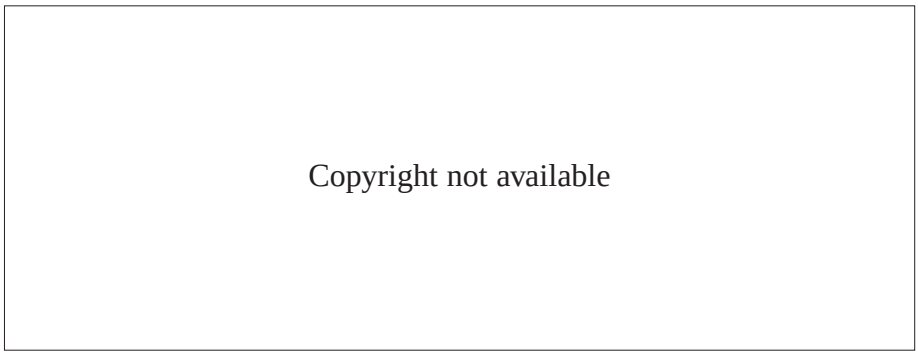
(i) Name TWO photographic techniques used in the study of life sciences.

(ii) Explain how each technique provides useful information.

**Question 14 continues on page 40**

QUESTION 14. (Continued) **Marks**

(f) Figure 1 shows a normal photograph of a foggy scene. Figure 2 shows the same scene photographed using an infra-red camera. **1**




Why does the infra-red photograph show more detail than the normal photograph?

(g) The production of black and white photographic negatives involves three important steps. The film is exposed to light, then developed and finally fixed. **7**

(i) When black and white film is exposed, light reacts with chemicals in the film to produce a latent image.

1. Name a light-sensitive chemical used in the manufacture of black and white photographic film.

2. Describe the chemical composition of the latent image formed when the film is exposed to light.

(ii) In the early days of black and white photography, film was not developed.

1. Explain how developing has improved the photographic process.

2. Name a substance commonly used to develop black and white film.

3. Describe, with the aid of a reduction half-equation, the reaction that occurs when black and white film is developed.

(iii) The final step in producing a negative for black and white photography is the process of fixing.

1. Identify a solution that may be used to fix a black and white film.

2. Describe, with the aid of a chemical equation, the process of fixing a black and white film.

3. Explain why it is necessary to fix a black and white film.

**End of question**

**QUESTION 15. Physics in Medicine** **Marks**

(a) Some medical conditions can be treated using $\beta$-particles. The emission of $\beta$-particles by a radioactive source is often followed by the emission of $\gamma$-rays. **4**

(i) Explain why $\beta$-particle emission is often followed by $\gamma$-ray emission.

(ii) Explain why $\beta$-particles can be used for medical treatment but not for medical diagnosis.

(iii) Describe ONE use of $\beta$-particles for medical treatment.

(iv) What safety precautions must be taken when using $\beta$-particles for medical treatment?

(b) The quality factor of $\alpha$-particles is 20 times that of $\beta$-particles. Explain the difference in the dose equivalent between $\alpha$-particles and $\beta$-particles. **1**

(c) A patient goes to the hospital with a possible blockage in a large artery. **3**

(i) Explain how ultrasound combined with the Doppler frequency shift can be used to detect the presence of the blockage.

(ii) The frequency $\left(f_r\right)$ at the receiver of a Doppler flowmeter is given by:

$$f_r = f\left(\frac{c-v}{c+v}\right).$$

For a particular test, the frequency of the ultrasound is $4 \times 10^5$ Hz and its speed in the blood is 1570 m $s^{-1}$. The Doppler frequency shift is 95 Hz. Calculate the velocity of the blood in the artery.

(d) Blood pressure can be measured using manual or automatic sphygmomanometers. **4**

(i) Draw a fully labelled diagram of a manual sphygmomanometer.

(ii) Describe how the systolic and diastolic pressures are detected using an automatic sphygmomanometer.

**Question 15 continues on page 42**

QUESTION 15. (Continued) **Marks**

(e) NMR imaging and CAT (CT) scans are two commonly used diagnostic techniques. **6**

For each technique,

(i) describe how the data for the images and scans are produced;

(ii) explain how computers make these techniques possible;

(iii) state one advantage over ultrasound.

(f) Radioactive isotopes are often used in medical investigations as tracers. **4**

(i) Name a radioactive isotope used as a tracer in medical investigations.

(ii) Explain the reason for using this isotope.

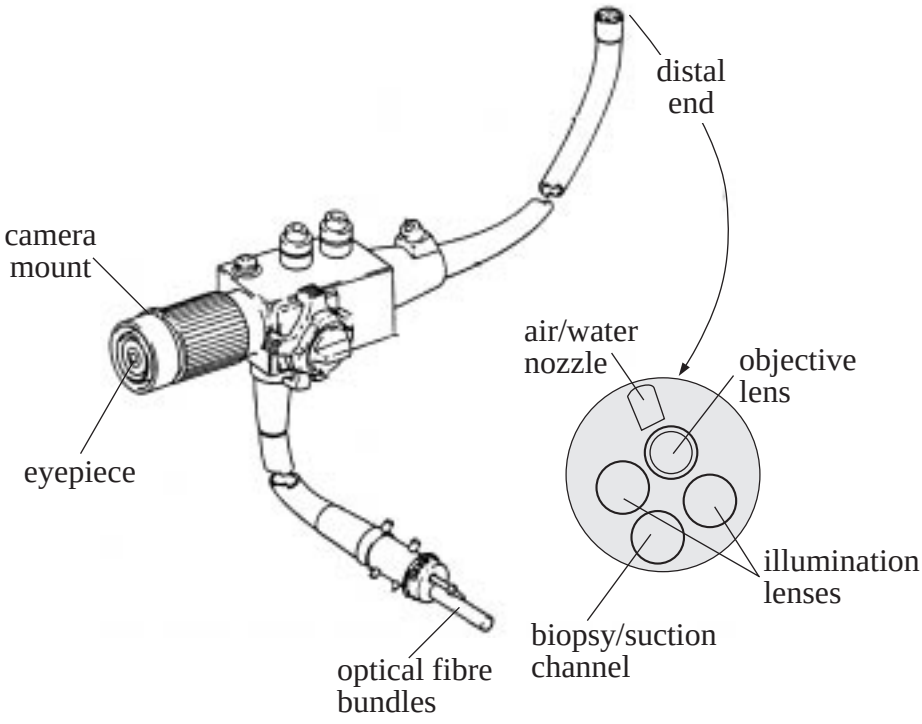
(iii) Describe how this radioactive isotope is used in the diagnosis of a medical condition.

**Question 15 continues on page 43**

QUESTION 15. (Continued) **Marks**

(g) The diagram shows an endoscope which could be used to examine a patient's stomach. This enables a doctor to make an internal but non-invasive examination. **3**

The light is delivered to each of the two illumination lenses using an incoherent fibre optic bundle. A coherent fibre optic bundle is connected to the objective lens.




*Martin Hollins, Medical Physics, Macmillan Education Ltd, 199©, Tomas Nelson & Sons Ltd*

(i) Explain how light is transmitted along an optical fibre. Diagrams may be useful.

(ii) Explain why a coherent bundle of fibres is required for the objective lens, while incoherent bundles can be used for the illumination lenses.

**End of question**

**QUESTION 16. Space Science** **Marks**

(a) Werner von Braun and his colleagues were the first to develop rockets for military use. **6**

The A-1 was their first prototype in a series. It was stabilised by a large fly-wheel and reached an altitude of only 2·4 km.

(i) Describe THREE improvements that led to the successful operation of the A-4 rocket (later known as the V-2).

(ii) The A-1 and A-4 rockets used the same fuel. Describe the fuel used in these rockets.

(iii) The American researcher, Robert Goddard, was independently developing and designing rockets during the same period. Describe the development of the stabilisation system for Goddard's rockets.

(b) Ion-thrust rockets were suggested by Robert Goddard as early as 1906. One particular type of ion engine was used in 1964 when a Scout booster ascended to an altitude of 4000 km using a cesium thruster. Explain how an alkali metal such as cesium can be used to provide ionic propulsion. **3**

(c) The two successful rocket propulsion systems on the space shuttle use solid and liquid fuels. Describe the purpose and function of each type of fuel. **3**

(d) Many satellites occupy geostationary orbits. **7**

(i) What is a geostationary orbit, and why is it useful for communications and navigation satellites?

(ii) The altitude of geostationary orbits is calculated using the equations:

A. $$v^2_{orbital} = G\frac{M_{Earth}}{R_{orbit}}$$

B. $$T = \frac{2\pi R_{orbit}}{v_{orbital}}$$ where $T$ is the period, the time taken for one orbit.

Explain the physical principle underlying the derivation of equation A.

(iii) Using equations A and B, and data on the data sheet, show that a geostationary satellite must have an altitude of approximately 36 000 km.

**Question 16 continues on page 45**

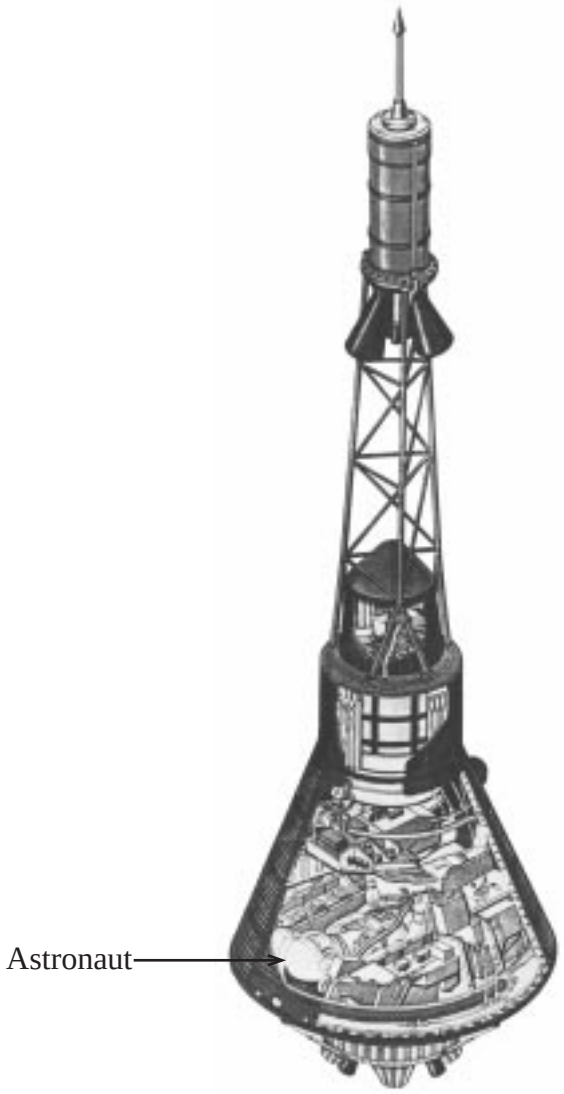
QUESTION 16. (Continued) **Marks**

(e) Recently a new lunar explorer has been investigating the Moon's composition. **3**

(i) Describe ONE important discovery made by this space probe.

(ii) What implications does this discovery have for theories of the Moon's origin?

(f) The first manned space flights from the USA were made in the Mercury capsule shown below. **3**




*The Illustrated Encyclopedia of Space Technology: a comprehensive history of space exploration, Landsdowne Press, p 63, © Salamander Books*

(i) Why was the astronaut seated as shown?

(ii) Describe TWO features of this capsule that increased the chances of human survival during re-entry and descent through the Earth's atmosphere.

**End of Paper 2**

BLANK PAGE

# SCIENCE 3/4 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, $R$ | $8{\cdot}314$ J K$^{-1}$ mol$^{-1}$<br>$0{\cdot}0821$ 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, $g$ | $9{\cdot}8$ 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, $\mu_0$ | $4\pi \times 10^{-7}$ 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 |

Aylward 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

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 H 1·008 Hydrogen | | | | | | | | | | | | | 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.

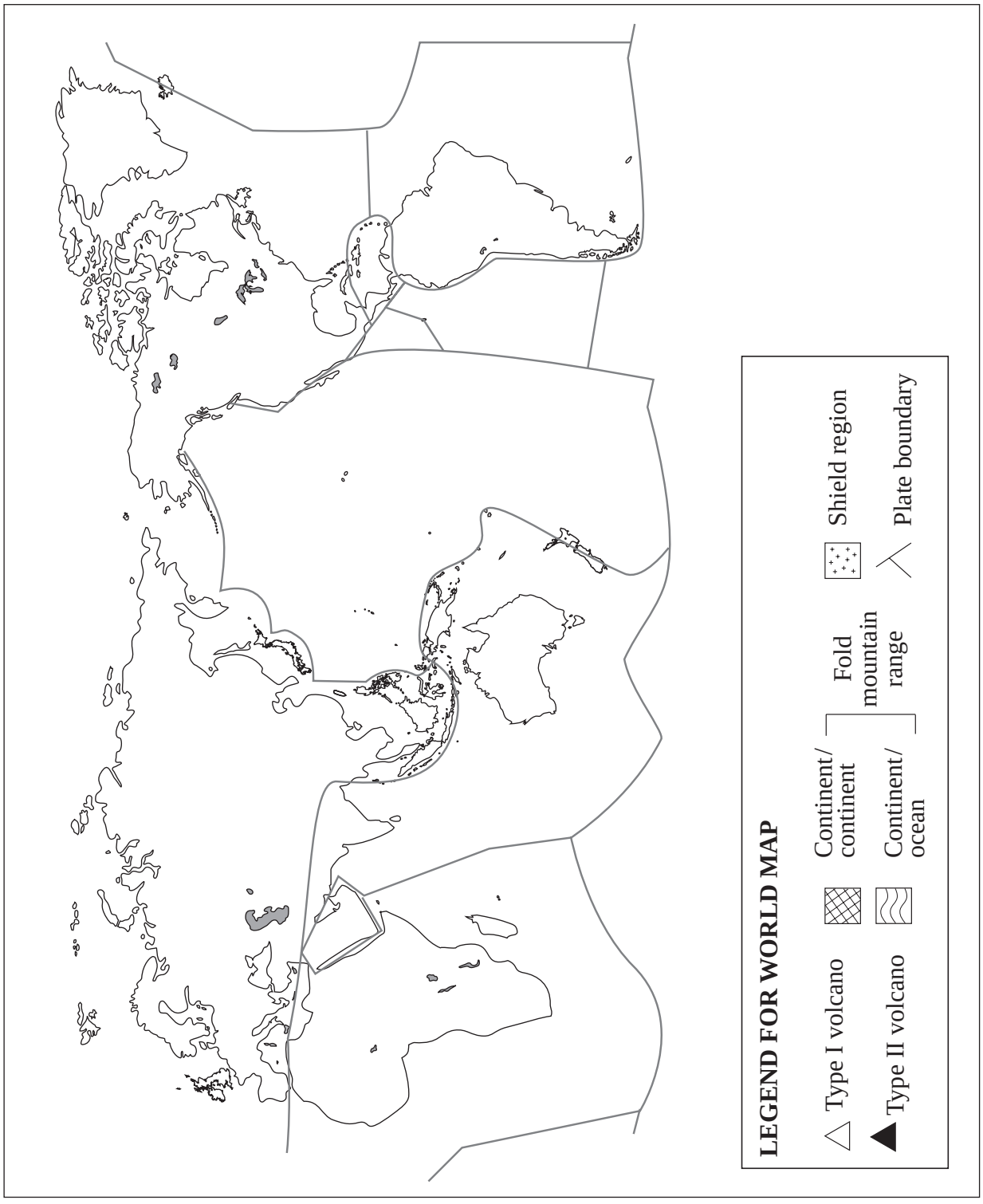
**MARKER'S USE ONLY**

**STUDENT NUMBER**

**1998**
**HIGHER SCHOOL CERTIFICATE EXAMINATION**
**SCIENCE 3/4 UNIT**
**PAPER 2—ELECTIVES, World Map**

**CENTRE NUMBER**

If you are attempting **QUESTION 9**, this page is to be detached, completed and attached to your Elective Answer Book for this question.



BLANK PAGE