BOARD OF STUDIES
NEW SOUTH WALES

**HIGHER SCHOOL CERTIFICATE EXAMINATION**

# 1999

# 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.

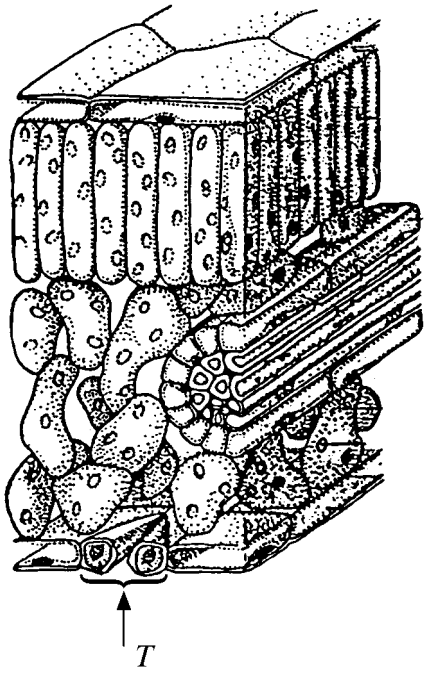
# CONTENTS

## GROUP 1—BIOLOGY ELECTIVES

**Marks**

### QUESTION 1 Flowering Plants and Mammals

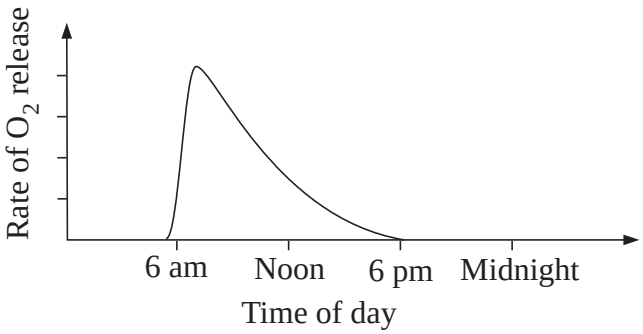
(a) The diagram below represents a generalised section of the leaf of a plant. **4**




(i) What is the name of structure *T*?

(ii) Describe the function of structure *T*.

(iii) A certain plant is found in a hot, dry climate. The graph below shows the rate of $O_2$ release from the leaves of that plant at different times during the day.




Explain fully the changes in the rate of oxygen release shown in the graph above over a 24-hour period.

**Question 1 continues on page 4**

QUESTION 1 (Continued) **Marks**

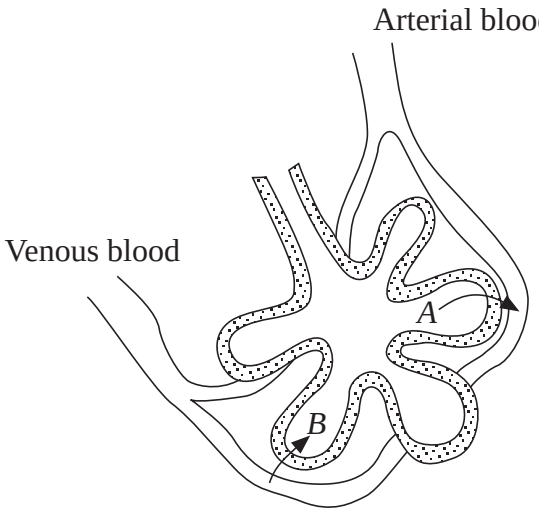
(b) In a flowering plant, the uptake of water and nutrients occurs mainly through one zone of the roots. The water and nutrients are then transported to the rest of the plant through specialised structures. **5**

(i) Name the specific zone of the root where the uptake of most water and minerals occurs.

(ii) Contrast the process for the uptake of minerals with the process for the uptake of water by the roots.

(iii) Name the specialised type of tissue through which water is transported from the roots to the leaves in a plant. Describe the structure of this tissue. A labelled diagram may be used.

(c) **5**




The diagram above shows a structure in mammals in which gaseous exchange occurs.

(i) Identify the substances represented by *A* and *B*.

(ii) Explain why substance *A* moves into the bloodstream.

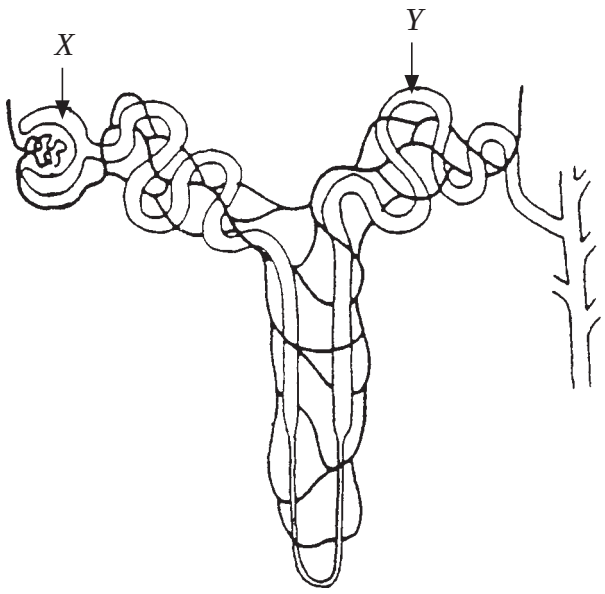
(iii) In what form is substance *A* transported by the blood?

(iv) Describe the main way by which substance *B* is transported in the blood.

**Question 1 continues on page 5**

QUESTION 1 (Continued) **Marks**

(d) The diagram below represents a nephron which is the basic filtering unit of the kidney. **5**




(i) Contrast the components of the filtrate solution at *X* and *Y*.

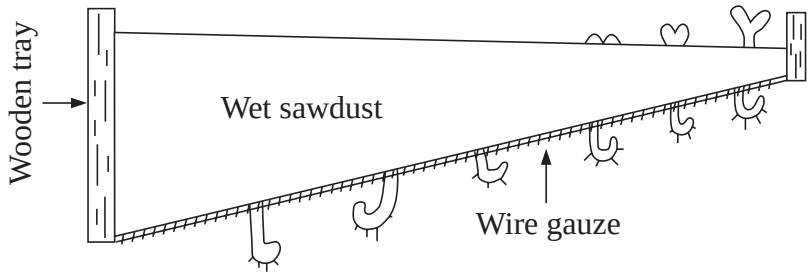
(ii) Explain the kidney's role in homeostasis.

(iii) Explain why the functioning kidney generates high amounts of heat.

**Question 1 continues on page 6**

QUESTION 1 (Continued) **Marks**

(e) The diagram relates to an experiment that was carried out on the responses of plants to environmental stimuli. **2**




Some radish seeds were placed onto the wire gauze base of a specially made tray and then were covered with wet sawdust. The box was suspended by strings in humid air. After two days, the roots had begun to grow through the gauze but after only a few more hours they bent back in the direction of the wet sawdust.

(i) What TWO environmental stimuli are being investigated in this experiment?

(ii) Choose ONE of these stimuli and explain the advantage of the plants' response.

(f) Reflexes are rapid, involuntary responses to stimuli. **4**

(i) Use a labelled diagram to show the arrangement of nerve cells that controls reflex responses to stimuli.

(ii) Why are these responses useful to the body?

**End of question**

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

(a) A class carried out a genetic study using garden peas. They examined two traits: pod shape, inflated or constricted, and seed colour, yellow or green. Sixty-four plants were grown from seed obtained from crossing two plants. **4**

The following plant phenotypes were obtained.

| *Number of inflated/green plants* | *Number of inflated/yellow plants* | *Number of constricted/green plants* | *Number of constricted/yellow plants* |
|---|---|---|---|
| 11 | 35 | 5 | 13 |

(i) Which alleles are phenotypically dominant? Explain your answer.

(ii) Are the parent plants homozygous or heterozygous for their genes controlling seed colour and pod shape? Explain your answer.

(b) A fly of the genus *Drosophila* has two phenotypes for eye colour: red and white. The gene controlling eye colour is only carried on the *X* chromosome. The red-eyed phenotype is dominant over the white-eyed phenotype. A red-eyed male is bred with a white-eyed female. In *Drosophila*, sex is determined in the same manner as in humans. **4**

(i) Show that, as a result of this cross, all male offspring have white eyes and all female offspring have red eyes.

(ii) If these offspring are cross-bred, what are the chances of producing a red-eyed male?

(c) Describe THREE ways in which sexual reproduction may contribute to phenotypic variation in a species. **3**

**Question 2 continues on page 8**

QUESTION 2 (Continued) **Marks**

(d) Human growth hormone (hGH) is a protein produced in the pituitary gland. This protein promotes normal growth processes in children. Pituitary dwarfism arises when a patient's pituitary gland is unable to produce sufficient quantities of hGH. Administering hGH to affected children may treat the condition. hGH used to be obtained from extracts from pituitary glands of deceased humans but is now produced by recombinant DNA technology. **5**

(i) What is meant by the phrase *recombinant DNA technology*?

(ii) Describe, using a diagram, how a plasmid may be used to produce hGH in bacteria such as *E. coli*.

(iii) Describe TWO advantages of producing hGH by recombinant technology as opposed to the extractive method described above.

(e) For EITHER tissue culture OR *in vitro* fertilisation, describe: **3**

(i) an application of the technology;

(ii) TWO technical aspects of the process.

(f) (i) Describe a difference in the structure of male gametes produced by mammals and those of flowering plants. Explain why this structural difference might have arisen. **4**

(ii) Explain how a virus might replicate.

(g) Use an example to explain the role of genes in cell differentiation. **2**

**End of question**

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

(a) In beer brewing, yeast is added to bring about fermentation. Sometimes, brews can become contaminated with bacteria such as lactobacilli. **5**

(i) Describe a method you could use to identify the presence of contaminating bacteria. Describe how you would isolate the contaminating bacteria as a pure culture for further examination.

(ii) Briefly describe a test you could use to help you identify the bacteria.

(iii) If you had access to an electron microscope, name TWO structures you might find in the yeast cell that you would not see in the bacterial cell.

(b) Identify a human disease that arises from a bacterial infection and a different human disease that arises from a viral infection. For each disease, describe a likely mode of transmission. **4**

(c) The immune system protects humans from a variety of diseases. **4**

(i) Describe ONE role of the lymphatic system in protecting the human body from disease.

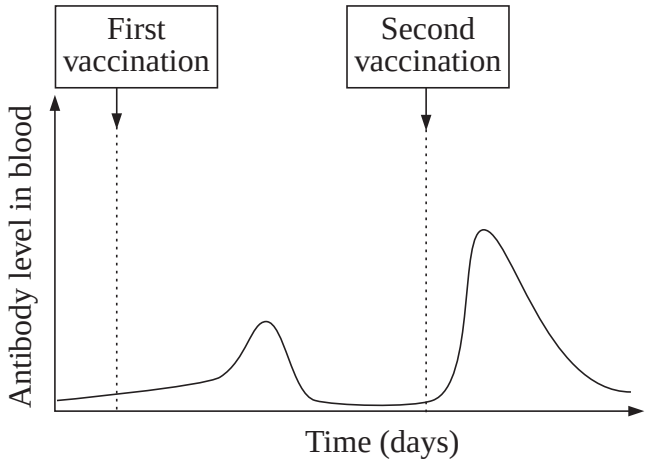
(ii) Describe a role of *B*-cells and a role of *T*-cells in the immunological response.

(iii) What is ONE difference between an antibody and an antibiotic?

**Question 3 continues on page 10**

QUESTION 3 (Continued) **Marks**

(d) Tetanus is an infectious disease that can be fatal in humans. Commonly, people are vaccinated to protect them from this disease. The following chart describes the variation of the antibody level in a patient with time. During this time two separate vaccinations were administered. **4**




(i) Describe TWO differences in the antibody response after the first and second vaccinations. Explain why these differences occur.

(ii) Explain the difference between active immunisation and passive immunisation.

(e) Name a micro-organism of industrial or economic importance. Describe its role in the process for which it is used. **2**

(f) Suppose that you are a medical practitioner. You are treating two patients who have presented with the symptoms of throat infections. The results from blood tests are returned to you from the pathology laboratory. They indicate that patient *A* has a bacterial infection and patient *B* has a viral infection. **2**

Comment on the appropriateness of prescribing antibiotics for the treatment of:

(i) patient *A*;

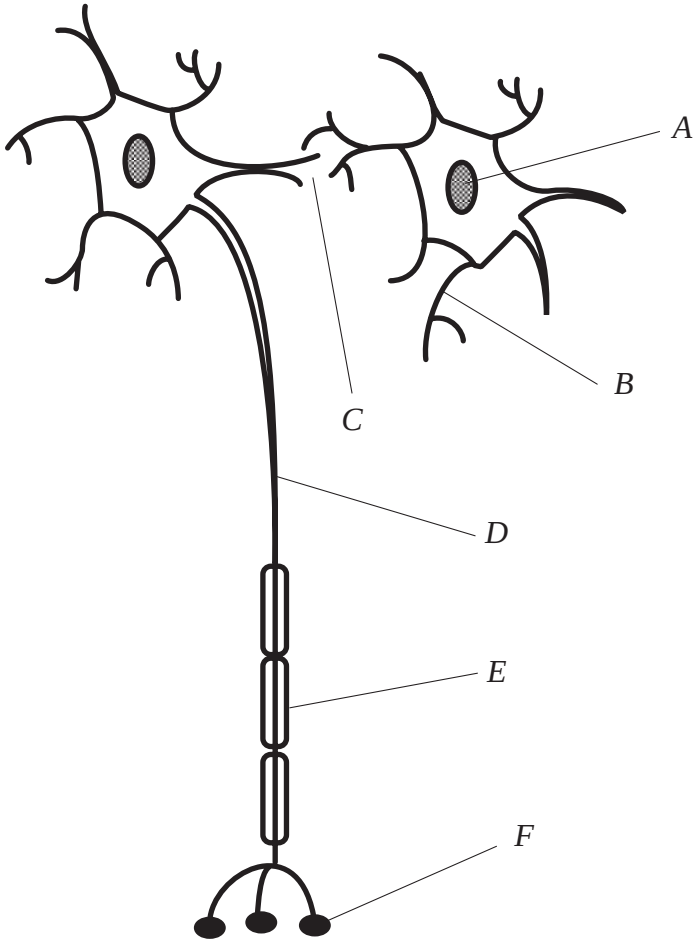
(ii) patient *B*.

(g) In a typical hospital environment, post-operative infections are commonplace, as is the widespread use of antibiotics to control these infections. In one hospital study in 1995 in Boston it was discovered that the proportion of infections that were NOT responding to a particular antibiotic increased with the increasing use of the antibiotic. Explain this phenomenon. **2**

(h) What is meant by *quarantine*? Give an example of goods that may be subject to quarantine. Explain why that material is subject to quarantine. **2**

**End of question**

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




(a) The diagram above shows two adjacent neurones. Identify the structures labelled *A* to *F*. **3**

(b) Nerve impulses are transmitted along neurones and between neurones. **5**

(i) A nerve impulse travels along a neurone as a wave of depolarisation. Use diagrams to explain this mechanism of impulse transmission.

(ii) A different mechanism is used to transmit the impulse between adjacent neurones. Describe this mechanism.

(c) (i) Name and describe TWO differences AND ONE similarity between the nervous system and the endocrine system. **4**

(ii) Describe a physiological response that involves the coordinated interaction between the nervous system and the endocrine system.

**Question 4 continues on page 12**

QUESTION 4 (Continued) **Marks**

(d) Name ONE animal hormone you have studied. Answer the following questions about that hormone. **5**

(i) In which organ is it produced?

(ii) Name a factor that influences the production of this hormone. Describe the effect of this factor on the production of the hormone.

(iii) How does the hormone act on target cells and what is their response?

(iv) What physiological effect does it have on the animal?

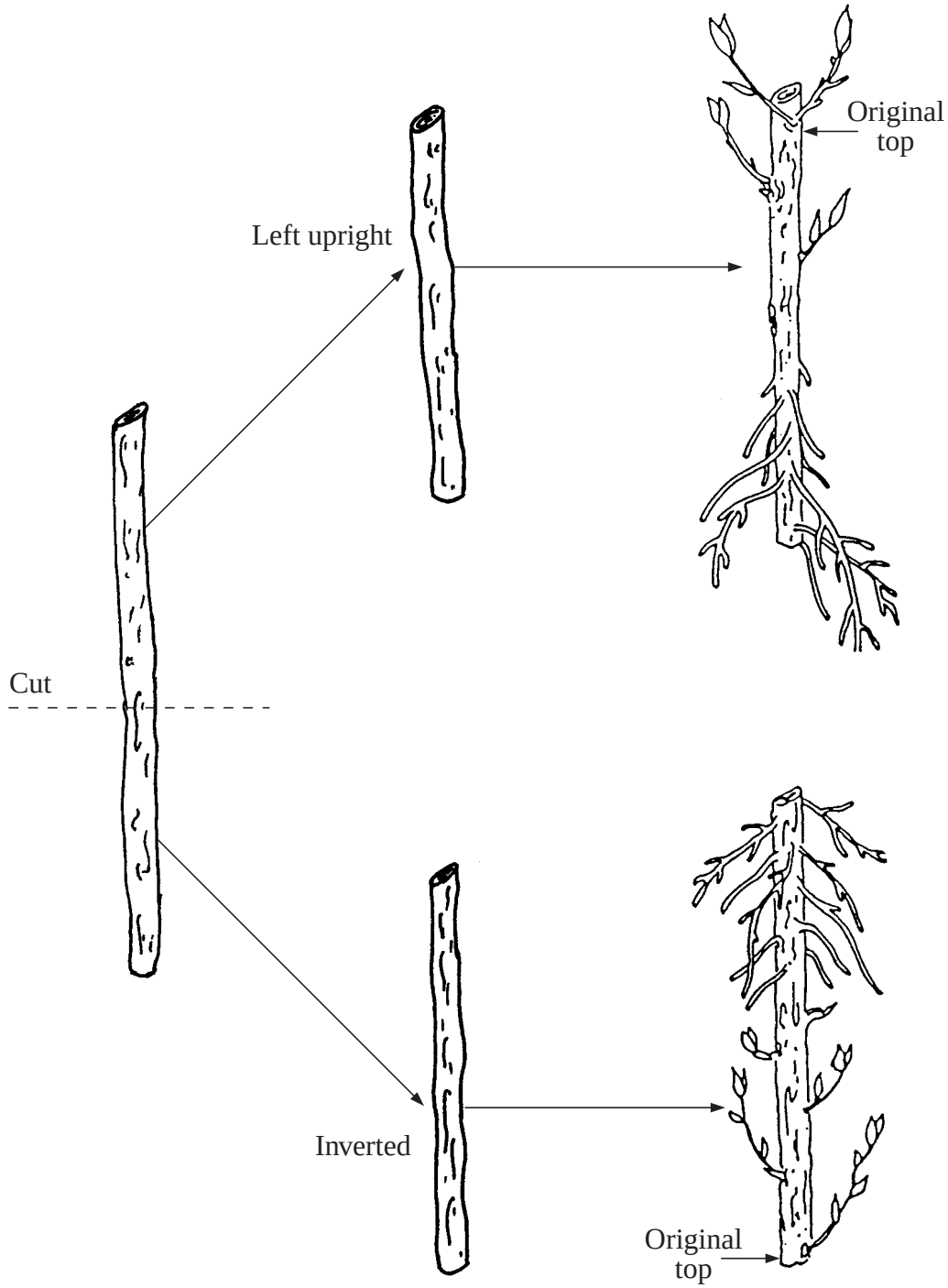
(e) Plants have both short-term and long-term responses to external stimuli. Describe the mechanism of each type of response. **3**

(f) Explain why the timing of plant flowering is important. State TWO environmental factors that determine when plants flower. **2**

**Question 4 continues on page 13**

QUESTION 4 (Continued) **Marks**

(g) The diagram depicts an experiment in which the stalk of a plant was cut into two sections. One section was inverted and both were maintained separately in a humid environment. **3**




Using your knowledge of plant cell responses, discuss what this experiment indicates about plant growth.

**End of question**

## GROUP 2—CHEMISTRY ELECTIVES

**Marks**

### QUESTION 5 Energy

(a) Use the information in the table to answer the following questions. **10**

| *Type of fuel* | *Ignition temperature at 101·3 kPa* (°C) | *Enthalpy of combustion* (kJ $mol^{-1}$) |
|---|---|---|
| Hydrogen | 580 | –286 |
| Ethyne | 335 | –1301 |
| Octane | 550 | –5470 |

(i) Define the term *ignition temperature*.

(ii) What does ignition temperature indicate about the safety of a fuel?

(iii) Each of the fuels above reacts with an oxidiser to produce heat. Name the most common oxidiser.

(iv) Write the equation, including the energy term, for the complete combustion of:

1 hydrogen;

2 ethyne.

(v) Which of the THREE fuels above produces the most energy in kJ $g^{-1}$? Show your working.

(vi) Octane is more likely to undergo partial combustion than ethyne. Explain why this would occur.

(vii) Give the formula of TWO chemical products that indicate that a partial or incomplete combustion reaction has occurred.

(viii) List TWO ways in which nuclear fuels differ from fossil fuels in their production of energy.

**Question 5 continues on page 15**

QUESTION 5 (Continued) **Marks**

(b) (i) Draw and fully label a diagram to illustrate an electrochemical cell producing electricity using a $Zn/Zn^{2+}$ half-cell and a $Fe^{2+}/Fe^{3+}$ half-cell. **8**

The following must be included on your diagram:

- flow of electrons
- flow of ions
- cathode
- anode
- salt bridge
- oxidation half-equation
- reduction half-equation.

(ii) State the function of the salt bridge.

(iii) What voltage would be produced by this cell, assuming standard conditions?

(iv) The above system is converted to an electrolytic cell.

1 What needs to be altered?

2 What material is used for the cathode?

3 What material is used for the anode?

**Question 5 continues on page 16**

QUESTION 5 (Continued) **Marks**

(c) (i) Use the information given in the table below to calculate the average bond energy for one C—C bond in the compound propene. **7**

| TABLE OF AVERAGE BOND ENERGIES | | | |
|---|---|---|---|
| *Bond* | *Energy* (kJ mol$^{-1}$) | *Bond* | *Energy* (kJ mol$^{-1}$) |
| C═C | 614 | H—C | 414 |
| C≡C | 839 | H—H | 436 |
| C—C | ? | H—O | 463 |
| C═O | 804 | C—O | 358 |
| | | O═O | 498 |

$\Delta_c H^{\ominus}_{(\text{propene}(g))} = -2058 \text{ kJ mol}^{-1}$

$\Delta_{vap} H^{\ominus}_{(H_2O(l))} = +44 \text{ kJ mol}^{-1}$

(ii) Name the TWO laws that are being used to determine the average bond energy of the C—C bond above.

(iii) Explain why bond energies are always stated as *average* bond energies.

**End of question**

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

(a) The elements fluorine and iodine are members of the same group. **5**

(i) What is the name of the group of the Periodic Table to which these elements belong?

(ii) List TWO properties that are similar for these elements.

(iii) List TWO properties that are different for these elements.

(b) Mendeleev and Meyer are two scientists who are credited with the major development of the Periodic Law. This Periodic Law has been changed and is now called the Modern Periodic Law. **10**

(i) Describe how the Modern Periodic Law differs from that originally proposed by Mendeleev and Meyer.

(ii) Which group of elements in the modern Periodic Table was missing from Mendeleev's table?

(iii) For EACH of the elements listed below, state to which group, period and block of elements it belongs.

1 beryllium

2 phosphorus

3 zinc (no group needed)

(iv) For the TWO elements, beryllium and phosphorus, give their electronic configurations in terms of shells and subshells for the:

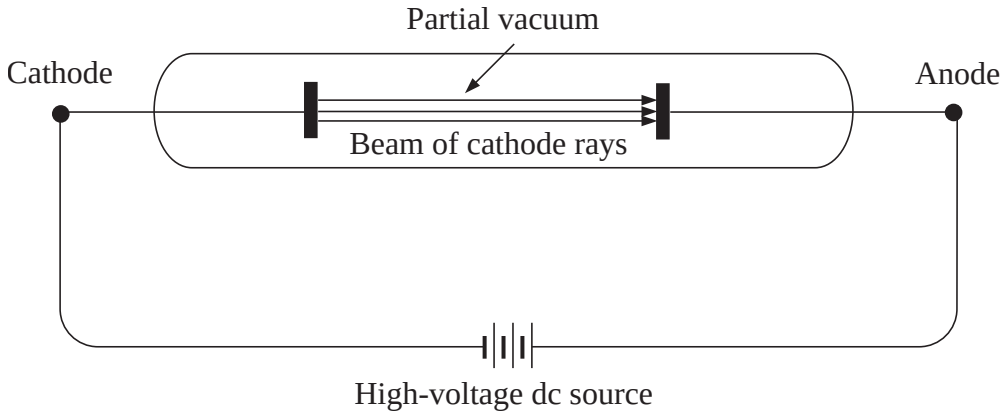
1 neutral element;

2 most stable ion.

**Question 6 continues on page 18**

QUESTION 6 (Continued) **Marks**

(c) The diagram represents a typical gas-discharge tube attached to a high-voltage source. This tube was used by a number of researchers in the late 1800s and early 1900s in their quest to understand the structure of the atom. **7**




(i) What was the name commonly given to these tubes after the 1870s?

(ii) Cathode rays are now known to be streams of negatively charged particles called electrons.

1 (I) Who first conclusively demonstrated that cathode rays were negatively charged particles?

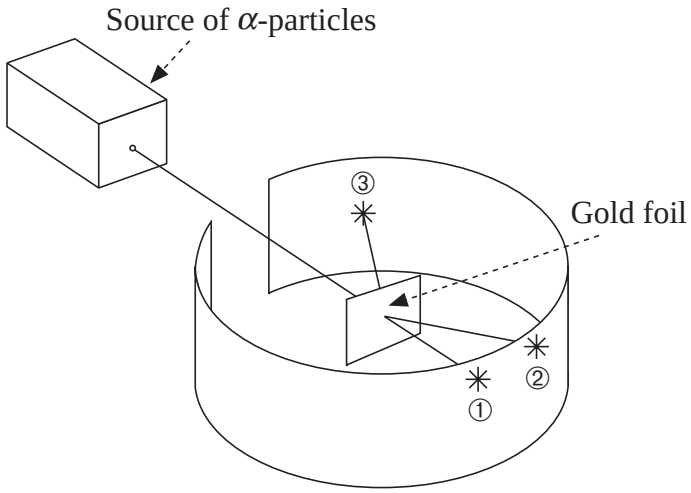
(II) Describe the experiment that indicated cathode rays were negatively charged.

2 Describe the experiment that was used to determine the ratio of charge to mass ($e/m$) for electrons.

**Question 6 continues on page 19**

QUESTION 6 (Continued) **Marks**

(d) The following experiment was carried out by Geiger and Marsden in Rutherford's laboratory. **3**




Explain, giving results and conclusions, what each of the detection areas (①, ② and ③) indicates about the structure of the atom.

**End of question**

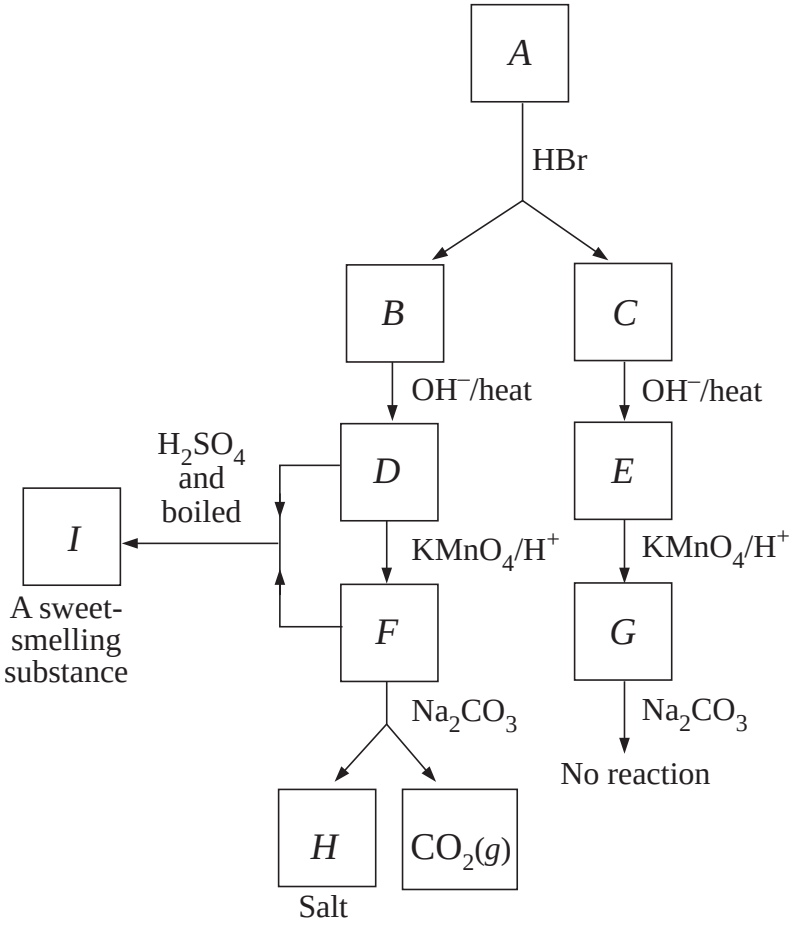
**QUESTION 7 Carbon Chemistry** **Marks**

Hydrocarbon *A* is composed of 85·7% carbon and 14·3% hydrogen. The molar mass of *A* was determined to be between 40 and 50 g.

(a) (i) Determine the molecular formula of compound *A*. **4**

(ii) Name compound *A* and give its structural formula.

(b) The flowchart below follows a sequence of reactions that occurs when using *A* as the starting material. **13**




(i) For each of the eight compounds *B* to *I*, give its IUPAC name.

(ii) Give ONE safety procedure that must be followed in the school laboratory when using organic compounds.

(iii) Reflux is the common technique used when compound *D* is reacted with *F* to produce *I*.

1 Draw and label a working reflux apparatus.

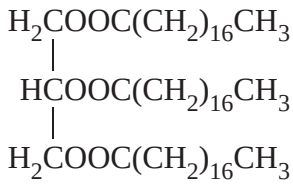
2 Give TWO reasons for using a reflux apparatus instead of boiling the mixture in an open beaker.

3 Draw and label the apparatus you would use to separate compound *I* in a pure form from the reaction mixture.

**Question 7 continues on page 21**

QUESTION 7 (Continued) **Marks**

(c) The fat, glyceryl tristearate, has the formula. **8**



When glyceryl tristearate is heated with a sodium hydroxide solution, sodium stearate is produced.

(i) To which group of chemicals do fats, such as glyceryl tristearate, belong?

(ii) The reaction of glyceryl tristearate with sodium hydroxide is known as saponification. Saponification is a specific example of what type of reaction?

(iii) Write the formula for sodium stearate.

(iv) Name ONE use for sodium stearate.

(v) Describe how the structure of sodium stearate enables it to carry out its function.

(vi) Name and give the formula for the other substance formed when glyceryl tristearate is reacted with sodium hydroxide.

(vii) State ONE use for the substance identified in part (vi).

**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 (h) must relate to the region named in part (a).

(a) Name the region you have studied.

(b) Draw a full-page map showing the outline of the region you have studied and naming TWO adjacent regions. **2**

(c) (i) Draw a labelled diagram of a specific structural feature in the region you have studied that has been produced by tectonic processes. **4**

(ii) Explain how this feature formed. Refer to tectonic processes operating during its formation.

(d) (i) Name TWO different types of fossils that occur in the region you have studied. **4**

(ii) In what Period(s) did these fossil organisms live?

(iii) Select ONE of these fossils. What does the occurrence of this fossil indicate about the environment in which it lived?

(iv) 1 Name TWO locations where either OR both of these fossils can be found.

2 Mark with an *F* each of these locations on your map in part (b) above.

**Question 8 continues on page 23**

QUESTION 8 (Continued) **Marks**

(e) (i) Name an igneous rock unit/formation that occurs in the region you have studied. **3**

(ii) Mark with an *I* its location on your map in part (b) above.

(iii) Describe the relationship between this igneous rock unit and adjacent rock units.

(f) Draw a simplified stratigraphic column to show the geological evolution of a location in the region you have studied. Your stratigraphic column should include the: **6**

(i) names of major formations;

(ii) major lithologies in each formation;

(iii) palaeoenvironment in which each formation was formed.

(g) (i) Name one major economic deposit that occurs in the region you have studied. **3**

(ii) State the main use(s) of the material extracted from this deposit.

(iii) Write an account of how the material in this deposit was formed or concentrated.

(iv) On your map in part (b) above, clearly identify the location of this deposit.

(h) Select ONE of the following features of special geological interest that you have studied for this Elective: **3**

- an artesian system
- a civil engineering project
- a spectacular scenic feature.

(i) Name your selected feature of special geological interest.

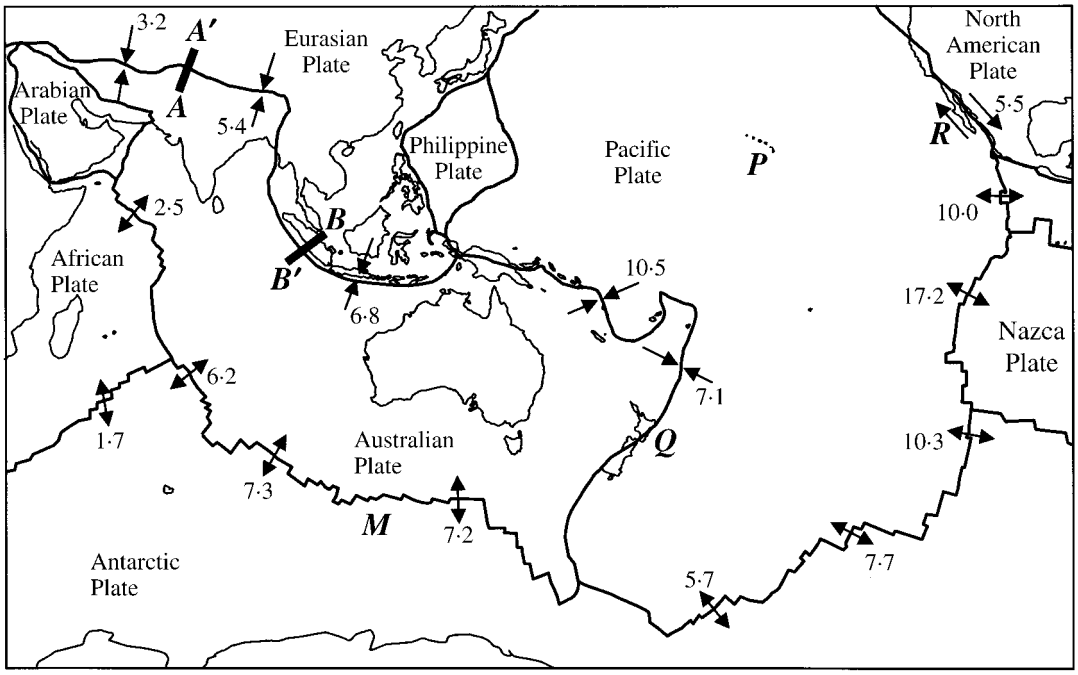
(ii) Mark with a *G* its location on your map in part (b) above.

(iii) Draw a labelled diagram to illustrate the geological characteristics of the feature you have selected.

**End of question**

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

(a) The map below shows the Australian, Pacific and surrounding plates, with the relative motion of plate boundaries in cm year$^{-1}$. **12**




(i) What are the differences between the processes leading to recent volcanic activity at sites *P* and *Q*?

(ii) What differences would exist between the magma composition and style of volcanism at sites *P* and *Q*?

(iii) Explain the step-like changes in the boundary between the Australian and Antarctic Plates in the vicinity of *M*.

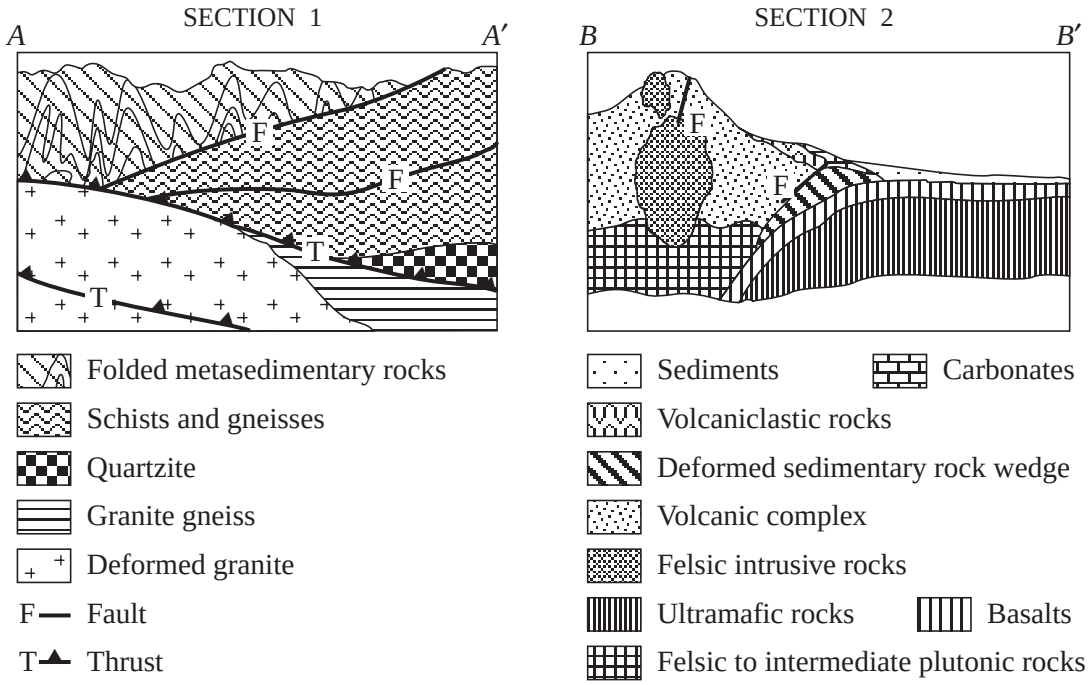
(iv) What differences would exist in the distribution of earthquake foci at localities *Q* and *R*?

(v) Why is the maximum age of crust in the present ocean basins typically much younger than crust of the continental land masses?

(vi) If the current spreading rates and plate boundaries are maintained, where are future continent–continent collisions involving the Australian continent likely to occur?

**Question 9 continues on page 25**

QUESTION 9 (Continued) **Marks**




(Sections are not drawn to scale)

(b) Schematic geological cross-sections of two active plate margins (*A*—*A*′) and (*B*—*B*′) are shown above. The locations of these sections are indicated on the map on page 24. **8**

(i) Compare the plate-tectonic setting of the two cross-sections. Describe the major differences in the tectonic and geological features present.

(ii) Why do extensive thrust faults and intense folding occur in Section 1 but not in Section 2?

(c) (i) Volcanic activity in regions similar to those of the Indonesian island chain causes various hazards to humans. **5**

1 Describe ONE such hazard.

2 Suggest how the hazard you have described might be avoided or mitigated.

(ii) The mountain chains along the central axis of Papua New Guinea or the northern boundary of India and Pakistan are typified by high local relief, frequent seismic activity and occasional heavy rainfall. Describe the potential effects of these characteristics on the local inhabitants and their activities.

**End of question**

## GROUP 4—PHYSICS ELECTIVES

**Marks**

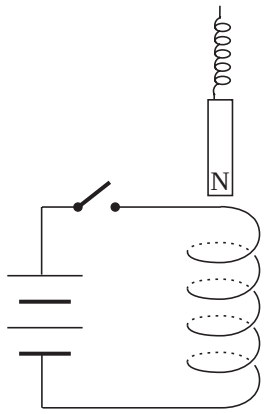
### QUESTION 10 Electromagnetism

(a) Wire *A* carries a current of 2·0 amperes directed into the page, 5·0 cm to the right of wire *B*. Wire *B* carries a current of 1·0 ampere out of the page. **5**

(i) Sketch this situation and the associated magnetic fields using conventional symbols.

(ii) Calculate the magnetic field strength midway between the two wires.

(b) A magnet was suspended from a spring over a coil. The north pole of the magnet was pointing down and the coil was part of a circuit as shown in the diagram. **5**




(i) Describe what would initially happen to the magnet and spring when the switch is closed. Explain your answer.

(ii) Give TWO ways in which the initial effect could be increased.

(c) A train is travelling at a speed of 40 km $h^{-1}$. In the region through which it is travelling, the vertical component of the Earth's magnetic field is $2{\cdot}5 \times 10^{-5}$ T. The metal wheels and axles form an electrical connection between the metal rails of the track. If the rails are 1·44 m apart, what is the electromotive force induced between the wheels? **2**

**Question 10 continues on page 27**

QUESTION 10 (Continued) **Marks**

(d) Induction motors are called induction motors because the relative motion of magnetic fields and electrical conductors induces e.m.f. and currents in the conductors. **13**

An induction motor is made up of two main parts, the rotor and the stator. Figure 1 shows this assembly.

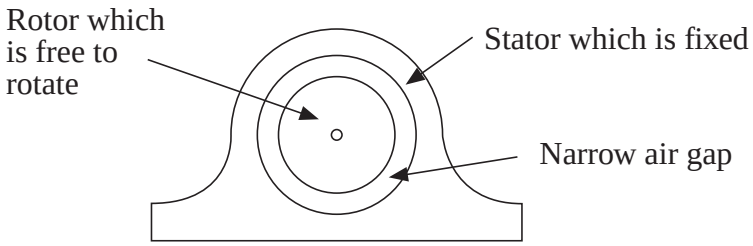



FIG. 1

When connected to an ac supply, the stator generates a magnetic field ($B$) that rotates around the air gap with constant speed ($v$).

The rotor is cylindrical in shape and has electrically conducting bars laid lengthwise, in slots, around its outside as suggested in Figure 2. At each end of the rotor the bars are electrically connected to each other.

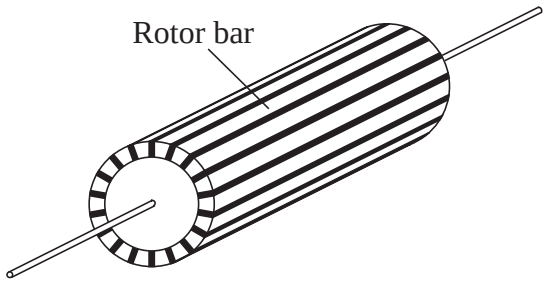



FIG. 2

(i) Explain, in terms of magnetic fields, electrical currents and other factors, what will happen to the rotor when it is stationary and the motor is first switched on.

(ii) What causes the rotor to turn?

(iii) Given that the rotor has conducting bars which are short-circuited, what prevents huge currents from flowing in the rotor and damaging it?

(iv) What determines the steady speed at which the motor operates under a constant load? Compare the speeds under a light load and under a heavy load. Explain your reasoning.

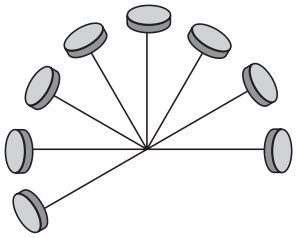
(v) Suppose that two adjacent rotor bars are each carrying a current of 120 A in the same direction, that their centres are 15 mm apart, and that they are 20 cm long.

Estimate the force exerted by one bar on the other. Will it be attractive or repulsive?

**End of question**

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

(a) A stroboscopic photograph was taken of part of the motion of a puck, of negligible thickness, moving with uniform circular motion at the end of a line. **5**



The frequency of the strobe light was 10 Hz, the puck had a mass of 0·20 kg, and the length of the line was 0·25 m. Calculate:

(i) the frequency of the puck's motion;

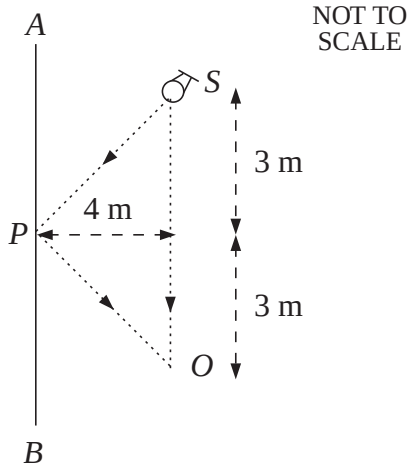
(ii) the linear (instantaneous) velocity of the puck;

(iii) the tension in the line.

**Question 11 continues on page 29**

QUESTION 11 (Continued) **Marks**

(b) A small loudspeaker (*S*) emits sound waves of frequency 680 Hz. The sound travels directly to the observer (*O*) who also receives sound waves that have reflected from the barrier *AB*, at point P as shown below. **5**




(i) For sound waves, name the wave type and describe the particle movement.

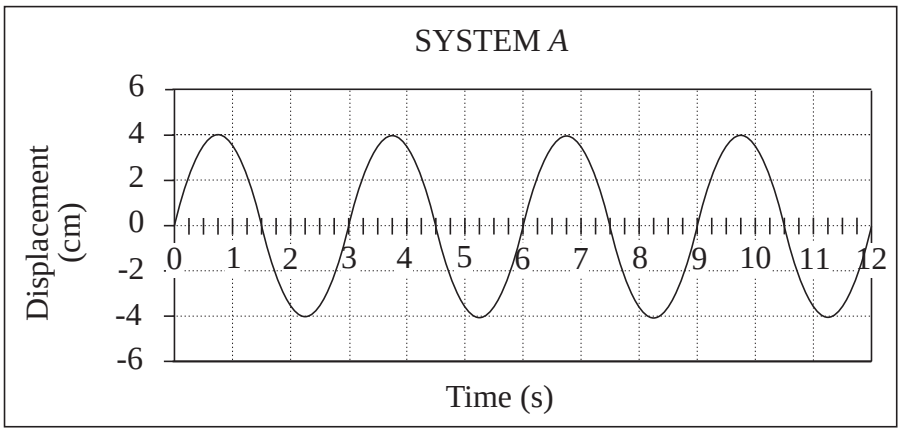
(ii) If the velocity of sound is 340 m $s^{-1}$ and the wave is unchanged by the reflection, what extra distance is covered by the reflected sound? Express your answer in terms of the wavelength.

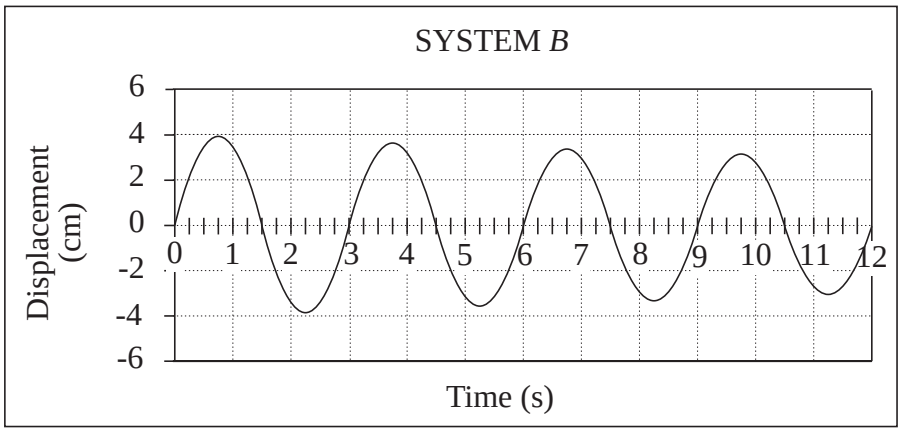
(iii) If the reflecting barrier *AB* is removed, what change in the sound will be heard by the observer? Explain your answer.

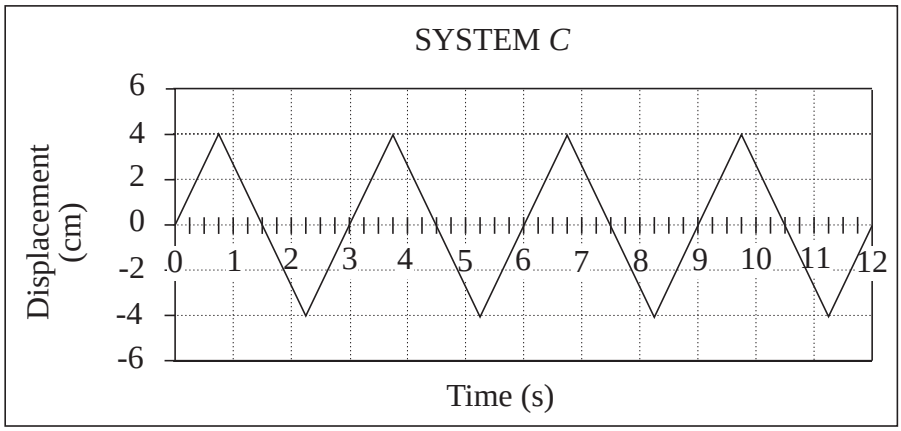
**Question 11 continues on page 30**

QUESTION 11 (Continued) **Marks**

(c) Three different systems *A*, *B* and *C* have displacement–time graphs as shown below. **10**




(i) Identify which of the systems exhibit simple harmonic motion (SHM). Give the amplitude and period for each of the SHMs.

(ii) What accounts for the behaviour of System *B*?

**Question 11 continues on page 31**

QUESTION 11 (Continued) **Marks**

(iii) It is suggested that one of the systems is a puck sliding on a frictionless, horizontal surface and undergoing elastic collisions with the walls at each end of the surface.

Identify the system that would fit the description and explain your reasons.

(iv) Take any one of the systems that you identified in part (b) (i) as undergoing SHM and treat it as if it were made up of a 2 kg mass attached to a spring with spring constant *k*.

Using the information in the graph for that system, calculate:

1 the value of *k*;

2 the magnitude of the maximum force on the mass.

(d) A student conducted an experiment in an attempt to measure the velocity of sound. She immersed a long open-ended glass tube in water. Then, as she slowly raised the tube, a tuning fork of frequency 480 Hz was sounded and held over the glass tube. The student noted that resonance occurred when the glass tube extended 0·16 m above the water and again at 0·51 m. **5**

(i) In terms of this experiment, explain what is meant by resonance.

(ii) Using these results, calculate the velocity of sound in air.

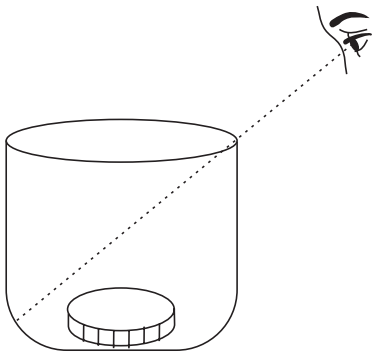
(iii) Explain why two resonance points were taken.

**End of question**

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

(a) (i) Christian Huygens suggested that light travelled as a wave. With the aid of a diagram, show how Huygens' theory explained the phenomenon of refraction. **5**

(ii) In a children's *Magic Book* there is a description of a trick that can be easily performed.



- Place a 20-cent piece at the bottom of a container.
- Position a person so that they cannot see the bottom of the container over the rim.
- Slowly fill the container with water and recite your magic words.
- 'Hey Presto!' . . . the coin comes into view.

With the aid of a diagram, explain the physics of this trick.

(b) (i) Reflecting surfaces are used to change the direction of light rays in many different ways. Use diagrams to show how: **6**

1 a parabolic mirror is used in the construction of spotlights;

2 a spherical mirror can be used to increase the size of the field of view.

(ii) A biconvex lens has a focal length of 35 mm. An object is placed at a distance of 80 mm from the lens with one end on the principal axis of the lens.

1 Construct a scale diagram to show the formation of the image in the situation described above.

2 Describe the image using the correct terminology.

**Question 12 continues on page 33**

QUESTION 12 (Continued) **Marks**

(c) A student directs a laser light of wavelength 680 nm through two narrow slits onto a screen 1·5 m from the slits. A series of light and dark bands appears on the screen. **5**

(i) Briefly explain why the pattern described above forms.

(ii) If the light bands are found to be 10 mm apart, calculate the distance separating the slits.

(iii) How would the pattern on the screen change if one of the slits was covered?

(d) Much of the scattered and reflected light in the environment is polarised. Polaroid sunglasses reduce glare by absorbing this polarised light. **3**

(i) What is meant by the term *polarised light*?

(ii) When purchasing sunglasses in a shop, how could they be tested to be sure they are Polaroid glasses?

(e) (i) Light is frequently referred to as an electromagnetic wave. Explain what *electromagnetic* means in this context. **6**

(ii) Describe the photoelectric effect. Include in your answer TWO characteristics of the effect that Einstein was able to explain and which the wave theory of light could not explain.

(iii) 1 There is a fundamental uncertainty about the nature of light which is summed up by the phrase *wave–particle dilemma*. Explain what is meant by that phrase.

2 Describe ONE piece of experimental evidence that supports the wave theory and that the particle theory has difficulty explaining.

**End of question**

## GROUP 5—INTERDISCIPLINARY ELECTIVES

**Marks**

### QUESTION 13 Biochemistry

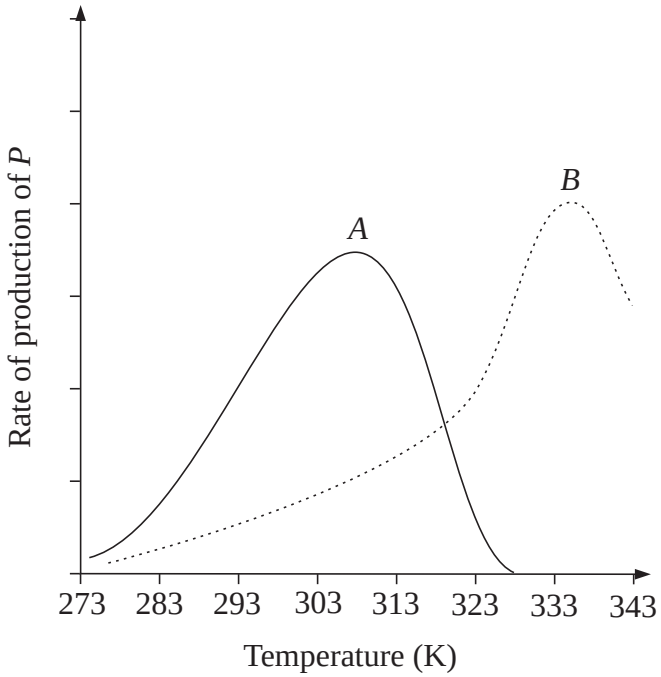
(a) Describe what is meant by the *primary*, *secondary* and *tertiary* structure of proteins. **3**

(b) (i) Explain what is meant by *enzyme specificity*. **2**

(ii) Two enzymes, *A* and *B*, catalyse the same reaction:

$$S \longrightarrow P.$$

They show the following activity behaviour with respect to temperature.




Which enzyme (*A* or *B*) is more likely to be a human enzyme? Explain your answer.

(c) What is meant by *protein denaturation*? **1**

**Question 13 continues on page 35**

QUESTION 13 (Continued) **Marks**

(d) A nutritionist wants to determine if a new food product contains protein. Suggest a distinguishing test for protein. **1**

(e) Plant cells can *fix* carbon from the atmosphere. **3**

(i) Name and describe the TWO stages involved in the fixation of carbon.

(ii) State where in the chloroplast each of these stages occurs.

(f) (i) In the nitrogen cycle of an ecosystem, describe the processes of: **5**

1 nitrification;

2 nitrogen fixation;

3 denitrification.

(ii) Name TWO metallic ions that plants obtain from the soil. State a role that each ion plays in plant cell structure or metabolism.

(g) Carcinogens, toxins, free radicals or radiation are all capable of modifying DNA in a manner that may be deleterious (harmful) to the organism. Base substitutions and deletions are the most common modifications. **4**

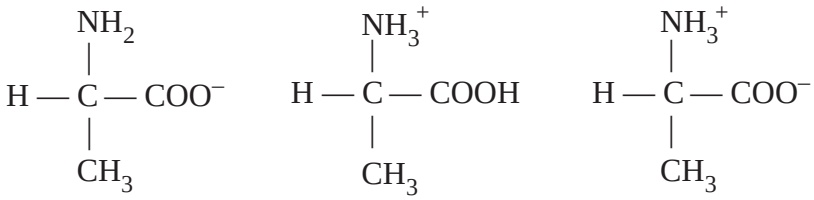
(i) How could a substitution affect the nature of the protein specified by a gene?

(ii) Why is the deletion of a base from a sequence potentially more serious than a substitution?

**Question 13 continues on page 36**

QUESTION 13 (Continued) **Marks**

(h) The structures below represent three ionisation states of the amino acid *alanine*. **3**



***A*** ***B*** ***C***

(i) Which of the structures *A*, *B* or *C* above represents the zwitterion form of alanine? Justify your answer.

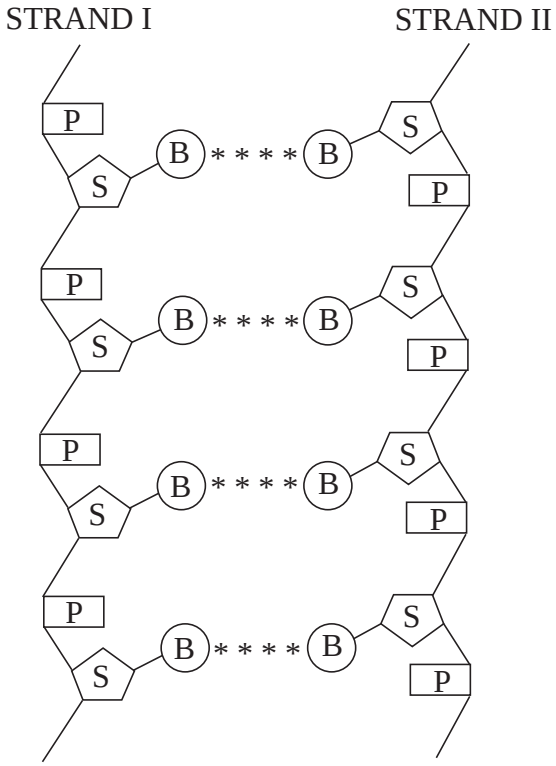
(ii) Which structure would exist at a pH of 1·0? Justify your answer.

(iii) Which structure would exist at a pH of 13·0? Justify your answer.

**Question 13 continues on page 37**

QUESTION 13 (Continued) **Marks**

(i) The schematic diagram below shows part of a DNA molecule. The asterisks (*) denote bonds between nucleotide bases (B) on complementary DNA strands. The backbones of the strands consist of alternating sugar (S) and phosphate (P) groups. **3**




(i) If molecules of DNA contain so many bases, why is it called deoxyribonucleic ACID?

(ii) Adenine (A), guanine (G), cytosine (C) and thymine (T) are the four types of bases. If the order of bases from top to bottom of STRAND I of this DNA molecule is TGAC, what would be the complementary sequence of bases down STRAND II?

(iii) Name the bonds that hold the two strands together.

**End of question**

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

(a) (i) A camera has a lens of 55 mm focal length. It takes a satisfactory exposure with a diaphragm setting of $f5{\cdot}6$ and a shutter speed of $\frac{1}{125}$ second. For artistic reasons, the photographer wants to decrease the shutter speed to $\frac{1}{30}$ second. **6**

Calculate the required diaphragm setting to achieve the same exposure on the film.

(ii) When light is incident on an air–glass interface, 4% of the light is reflected, meaning that 96% is transmitted. A certain camera lens is made up of 3 glass elements, each separated from the others by air.

Calculate the proportion of the incident light that emerges from the rear of the lens.

(iii) The elements in part (ii) are coated so that they now reflect only 1% of the incident light at each interface. What is now the proportion of transmitted light to incident light for the lens?

(iv) Name ONE other advantage provided by anti-reflection coatings on lens elements.

(b) Figure 1 is a graph of reflectance vs wavelength for soil, vegetation and water. **3**

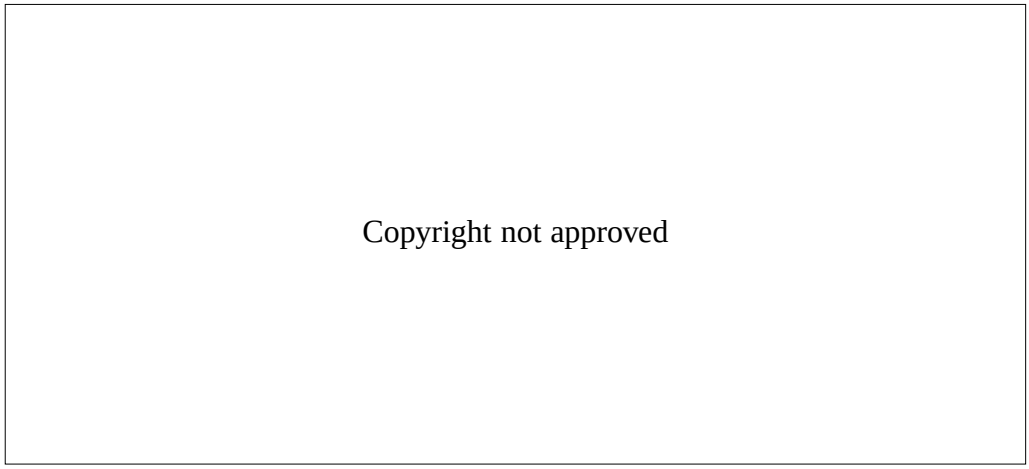



FIGURE 1

In *Landsat* satellites there are four scanners covering parts of the electromagnetic spectrum as follows:

- Band 4: $0{\cdot}5$–$0{\cdot}6\,\mu$m (green)
- Band 5: $0{\cdot}6$–$0{\cdot}7\,\mu$m (red)
- Band 6: $0{\cdot}7$–$0{\cdot}8\,\mu$m (near infra-red)
- Band 7: $0{\cdot}8$–$1{\cdot}1\,\mu$m (near mid-infra-red).

**Question 14 continues on page 39**

QUESTION 14 (Continued) **Marks**

Figure 2 shows photographs taken in each of the four bands. Figure 2 (A) is taken in Band 4, Figure 2 (B) is taken in Band 5, Figure 2 (C) is taken in Band 6 and Figure 2 (D) is taken in Band 7.

In Figure 2 the same feature is circled in all four parts (A), (B), (C) and (D).

Identify the make-up of that feature. Explain your reasoning.

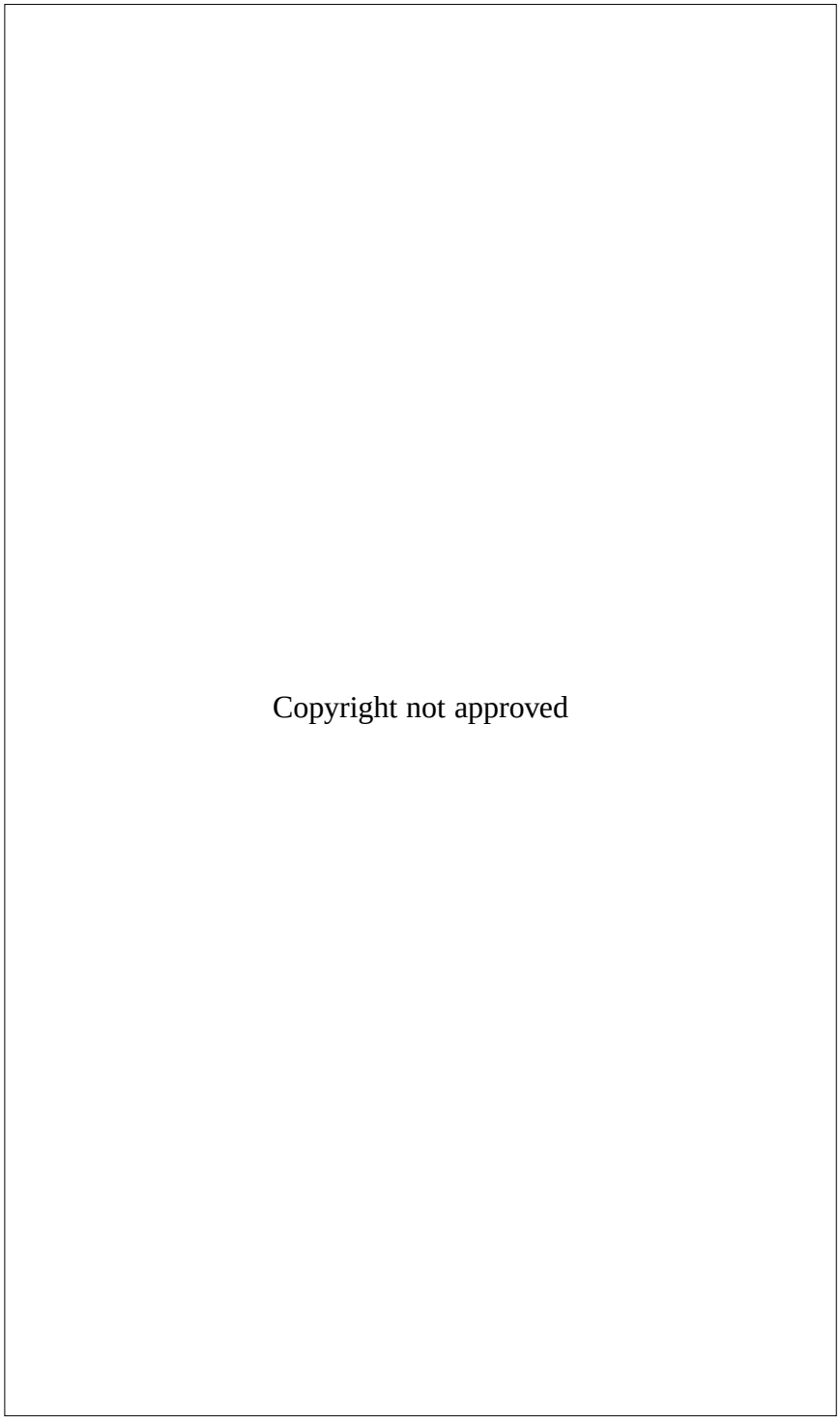



FIGURE 2

**Question 14 continues on page 40**

QUESTION 14 (Continued) **Marks**

(c) (i) Very simple cameras had leaf shutters. Many modern cameras have focal-plane shutters. Explain how a focal-plane shutter works and how it provides for a wide range of shutter speeds. **5**

(ii) Why is the positioning of a focal-plane shutter a major advantage?

(iii) What is a disadvantage of a focal-plane shutter when photographing rapid movement? Explain how this disadvantage arises.

(d) A simple lens has a number of defects, or aberrations, that limit the sharpness of the image that it can produce. These aberrations include: **3**

(i) spherical aberration;

(ii) chromatic aberration.

Describe the effect of each of these aberrations.

(iii) Name the single simple method that will reduce the effects of both these aberrations.

(e) There are three stages in processing black and white film. The film is exposed to light to produce a latent image, then it is developed, and finally the film is fixed. At this stage the film is known as a negative. **8**

(i) What is the latent image formed when the film is exposed to light?

(ii) Developers are mixtures of chemicals, each with a specific function. Describe the purpose of the chemical that acts as:

1 a reductant;

2 an accelerator;

3 a preservative;

4 a restrainer.

(iii) Describe THREE factors that may affect the successful developing of the film.

**End of question**

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

(a) When doctors wish to study an unborn child they usually use the technique of ultrasonics rather than X-rays. **6**

(i) Describe the nature of the radiation used in:

1 ultrasonics;

2 X-rays.

(ii) How is an image formed by:

1 ultrasonics?

2 X-rays?

(iii) 1 Why is it considered safer to use ultrasonics than X-rays, particularly when studying a young unborn child?

2 During ultrasonic procedures a gel is commonly used. What is the main function of the gel?

(b) Ultrasonics may be used to measure the rate of blood flow through blood vessels. This technique makes use of the Doppler frequency shift. **5**

(i) What are the physical principles giving rise to the Doppler shift?

(ii) Use a labelled diagram to explain how ultrasonics may be used to measure the rate of blood flow in a blood vessel.

**Question 15 continues on page 42**

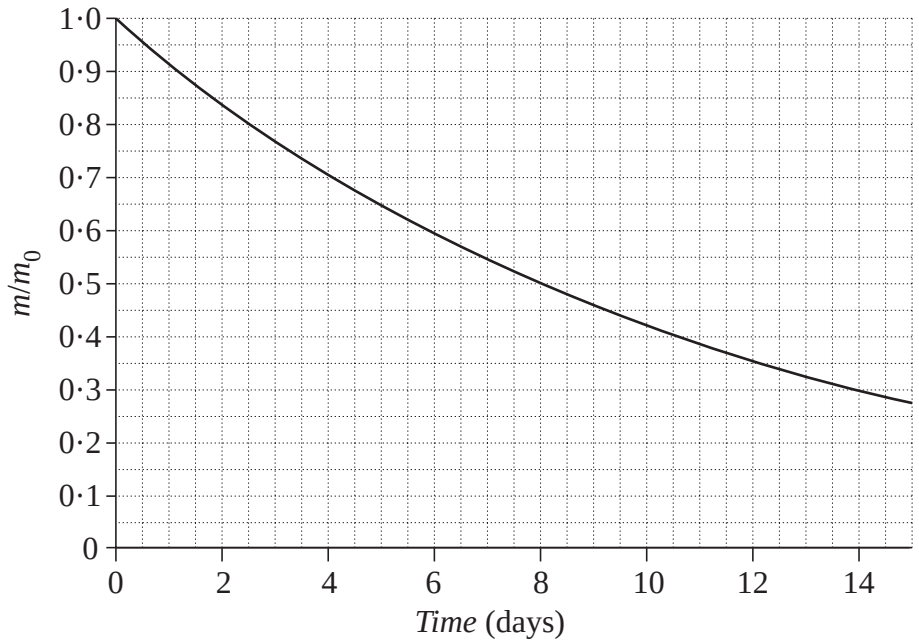
QUESTION 15 (Continued) **Marks**

(c) Iodine-125 ($^{125}$I) and iodine-131 ($^{131}$I) are two radioactive isotopes used in various medical applications. **8**

$^{125}$I has a half-life of 60·1 days and decays by electron capture, emitting X-rays of energy 27 keV. It is used in the treatment of prostate cancer by implanting a number of *seeds*, containing $^{125}$I, directly into the tumour.

$^{131}$I decays by emitting a $\beta$-particle and then a $\gamma$-ray, but it does so in a number of different ways. However the main decay mechanism involves the emission of a $\beta$-particle with a maximum kinetic energy of 606 keV followed by a $\gamma$-ray of energy 364 keV. It is commonly used to study the thyroid gland where the patient drinks a solution of sodium iodide (NaI) containing $^{131}$I. A normal thyroid will take up 12% of the iodine that has been administered.

(i) The decay curve for $^{131}$I is graphed below.




1 Determine the half-life of $^{131}$I.

2 A sample of sodium iodide contained $1 \times 10^{-10}$ g of $^{131}$I when it was prepared and transported interstate. Three days after being prepared it was injected into a patient.

(I) What mass of $^{131}$I would remain in the sample after 3 days?

(II) What mass of $^{131}$I would be taken up by a normal thyroid?

3 How could the ability of the thyroid to take up the iodine be determined?

**Question 15 continues on page 43**

QUESTION 15 (Continued) **Marks**

(ii) 1 What is the major property of X-rays and $\gamma$-rays that affects their absorption by biological tissue?

Referring back to the information given above part (i):

2 give TWO reasons why $^{131}I$ is preferred to $^{125}I$ for examining the thyroid gland;

3 give TWO reasons why $^{125}I$ is preferred to $^{131}I$ for treating prostate cancer.

(d) Two diagnostic tools commonly used in medicine are EEG and ECG machines. **3**

(i) What is the full name of each machine?

(ii) Which part of the patient's body is investigated by:

1 the EEG machine?

2 the ECG machine?

(iii) What physical quantity is measured by both machines?

(e) The sphygmomanometer is commonly used by medical practitioners to measure the blood pressure of a patient. Two readings, such as 120 over 75, are obtained when a patient's blood pressure is measured. **3**

(i) What name is given to:

1 the reading of 120?

2 the reading of 75?

(ii) Explain what is happening in the patient's blood vessels to produce these two measurements.

**End of question**

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

(a) Recent data from the Hubble telescope and other sources suggest that Pluto might not be a true planet of our solar system. Instead, it could be a captured satellite. **2**

Given that we are presently unable to obtain material from Pluto, provide TWO pieces of information about Pluto that have led scientists to believe that it is indeed a captured satellite rather than a true planet.

(b) The quest to find extraterrestrial life has gathered pace in recent years with probes such as the Mars Explorer. This quest has been supported by discoveries on Earth. **2**

Describe ONE recent discovery about life forms on Earth that has led to a higher expectation of finding life on other planets.

(c) Goddard and von Braun were pioneers in rocket technology. Outline a technical development with which each has been credited. **2**

(d) Following World War II, rocket development was continued by the USA and USSR in what became known as the Space Race. Soviet scientists achieved several firsts during this period. Describe THREE of these achievements. **3**

(e) What was a major achievement of the: **2**

(i) Gemini series of missions?

(ii) Apollo series of missions?

(f) Skylab was developed in 1974. **2**

(i) What was Skylab?

(ii) Why was it significant?

(g) Propulsion systems that do not use chemical propellants are being investigated. Name ONE of these systems and describe how it could be used to propel a rocket. **2**

**Question 16 continues on page 45**

QUESTION 16 (Continued) **Marks**

(h) State THREE essential functions of a life support system for extended space travel. **3**

For ONE of these functions, describe how a space vehicle would be designed to implement this part of the life support system.

(i) The simplest theory for the motion of a satellite assumes a circular orbit where the centripetal force required to keep the satellite in its orbit is provided by the gravitational pull of the central body. **7**

The centripetal force is given by:

$$F_C = \frac{mv^2}{R}$$

where $m$ is the mass of the satellite, $v$ is its velocity in orbit, and $R$ is the radius of the orbit. The gravitational pull is given by:

$$F_G = G\frac{Mm}{R^2}$$

where $M$ is the mass of the central body and $m$ and $R$ have already been defined.

(i) Use the equations above to derive Kepler's Third Law relating the radius of the orbit to the orbital period of the satellite.

(ii) What are the TWO most important characteristics of a *geostationary* satellite?

(iii) Many Earth-monitoring satellites have near-polar orbits and periods of about 100 minutes.

What is the main reason for the near-polar orbits?

(iv) The radius of the Moon's orbit is $3{\cdot}84 \times 10^5$ km and the Moon's period is 27·3 days. The radius of the Earth is $6{\cdot}33 \times 10^3$ km.

What is the required altitude for a satellite with a period of 100 minutes?

**End of Paper 2**

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# 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* (4th Edition) is the principal source of chemical data for this examination paper. Some data may have been modified for examination purposes.

# PERIODIC TABLE

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 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 | | | | | | | | | | | | |

KEY

Atomic Number — 79 — Symbol of element

Atomic Mass — 197·0 — Au — Name of element (Gold)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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.