BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1997
SCIENCE
3/4 UNIT
PAPER 1—CORE

Time allowed—Three hours
(Plus 5 minutes reading time)

DIRECTIONS TO CANDIDATES

- Attempt ALL questions.
- **Section I** 10 multiple-choice questions, each worth 1 mark. Mark your answers in pencil on the Answer Sheet provided.
- **Section II** 10 questions, each worth 3 marks. Answer this Section in the Section II Answer Book.
- **Section III** 8 questions, each worth 5 marks. Answer this Section in the Section III Answer Book.
- **Section IV** 2 questions, each worth 10 marks. Answer this Section in the Section IV Answer Book.
- You may keep this Question Book. Anything written in the Question Book will NOT be marked.
- 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.

SECTION I

Attempt ALL questions.

Questions 1–10 are worth 1 mark each.

Mark your answers in pencil on the Answer Sheet provided.

Select the alternative A, B, C, or D that best answers the question.

1. Phosphoric acid, H_3PO_4, can be formed from solid phosphorus, P_4, according to the overall equation

$$P_4(s) + 5O_2(g) + 6H_2O(l) \rightarrow 4H_3PO_4(l).$$

The mass of H_3PO_4 that could be produced from 124 g of P_4 is

(A) 98 g.

(B) 124 g.

(C) 392 g.

(D) 496 g.

2. In an industrial process, coke is used as a source of carbon for extracting metals from their ores. Which of the following metals could NOT be extracted from its main ore by using coke?

(A) Aluminium

(B) Copper

(C) Iron

(D) Mercury

3. Which of the following substances in the liquid state has polar molecules and a significant degree of intermolecular hydrogen bonding?

(A) Hydrogen

(B) Methane

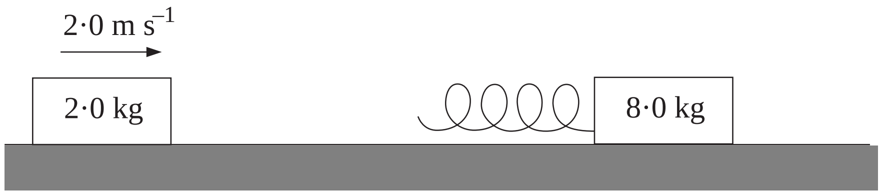
(C) Methanol

(D) Sodium chloride

4 . A farmer determined the pH of four soil samples. Which of the samples is likely to contain the lowest concentration of hydrogen ions?

	Soil sample	pH
(A)	*A*	5·6
(B)	*B*	6·0
(C)	*C*	7·6
(D)	*D*	8·0

5 . A 2·0 kg mass is moving at 2·0 m s^{-1} on a horizontal frictionless surface. It collides elastically with a stationary 8·0 kg mass which is fitted with a spring of negligible mass. The spring is compressed in the collision. At the point of maximum compression, both masses have the same velocity.



The momentum of the system of masses plus spring at maximum compression, is

(A) 0 kg m s^{-1}.

(B) 2·0 kg m s^{-1}.

(C) 4·0 kg m s^{-1}.

(D) 8·0 kg m s^{-1}.

6 . Assuming there is no friction, the greatest amount of work done on a 0·6 kg mass is when it is

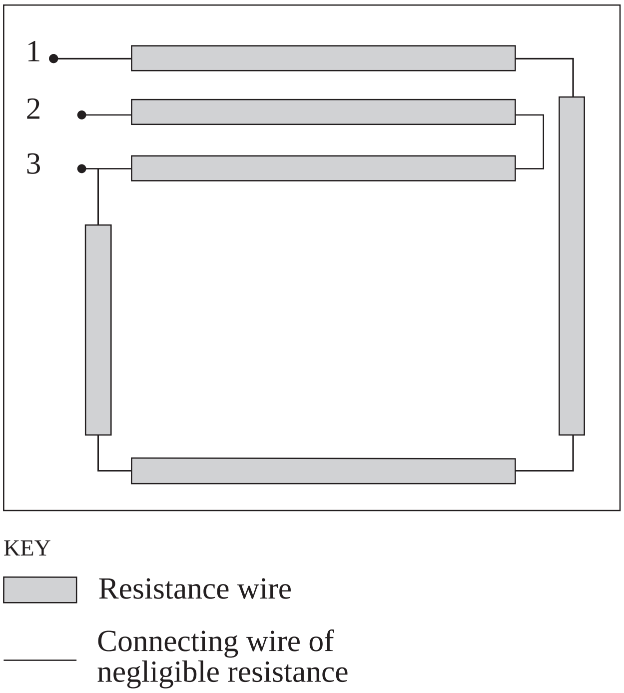
(A) raised through a height of 11 metres.

(B) accelerated from rest to a speed of 15 m s^{-1}.

(C) moved horizontally over a distance of 500 metres.

(D) taken over a 200 metres high hill and returned to its starting point.

7 . The schematic diagram below shows the arrangement of uniform resistance wires inside an electric blanket.



Which terminals must be connected to a power supply in order to produce the greatest heating effect by the blanket?

(A) 1 only

(B) 1 and 2

(C) 1 and 3

(D) 2 and 3

8 . The cell structures directly involved in protein synthesis include

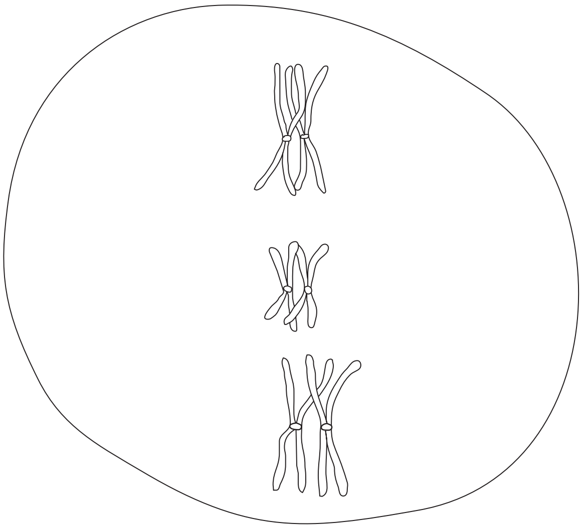
(A) endoplasmic reticulum, nucleus, ribosomes.

(B) chloroplasts, nucleus, endoplasmic reticulum.

(C) mitochondria, nucleus, vacuoles.

(D) vacuoles, chloroplasts, ribosomes.

9 . The diagram shows an animal cell.



This cell is undergoing

(A) cytokinesis.
(B) glycolysis.
(C) meiosis.
(D) mitosis.

1 0 . Of the following, the earliest lifeforms on Earth were

(A) armour-plated fish.
(B) filamentous bacteria.
(C) giant jellyfish.
(D) unicellular algae.

SECTION II

Attempt ALL questions.

Questions 11–20 are worth 3 marks each.

Answer this Section in the Section II Answer Book.

Show all necessary working in questions involving calculations.

Marks may be awarded for relevant working.

11. An organic substance consisting of carbon, hydrogen, and oxygen, was exploded with 12·672 g of oxygen. The products were 15·488 g of carbon dioxide and 7·9200 g of water. The molar mass of the organic substance was 488·00 g mol^{-1}.

(a) Calculate the empirical formula for the organic substance.

(b) What is the molecular formula of the organic substance?

12. A group of students is required to do a titration. Initially they are asked to dilute 60·0 mL of a 3·000 mol L^{-1} sodium hydrogen carbonate stock solution to 0·1000 mol L^{-1}. Then they titrate a 25·0 mL aliquot of this diluted solution against a 0·0750 mol L^{-1} sodium hydroxide solution.

(a) Write a balanced equation to represent this reaction.

(b) What volume of water is required to dilute the stock solution of sodium hydrogen carbonate to 0·1000 mol L^{-1}?

(c) Calculate the volume of sodium hydroxide solution required to neutralise the 25·0 mL aliquot of sodium hydrogen carbonate.

13. The formulae of three biochemical molecules are as follows:

X	*Y*	*Z*
$(C_6H_{11}O_5)O(C_6H_{11}O_5)$	$HOOCCH_2CH_2NH_2$	$CH_2OOC(CH_2)_{16}CH_3$ | $CHOOC(CH_2)_{16}CH_3$ | $CH_2OOC(CH_2)_{16}CH_3$

Complete the table in the Section II Answer Book.

14. The mass of 0·5000 L of an unknown gas at 298 K and 101·3 kPa is 1·309 g. The unknown gas is one of the following: SO_2, CO_2, P_2O_5, or NO_2.

(a) (i) Calculate the molecular mass in grams of the unknown gas.

(ii) Name the gas.

(b) The gas is bubbled into water.

(i) Write the equation for the reaction that occurs.

(ii) Is the solution that is produced acidic or basic? Explain your answer.

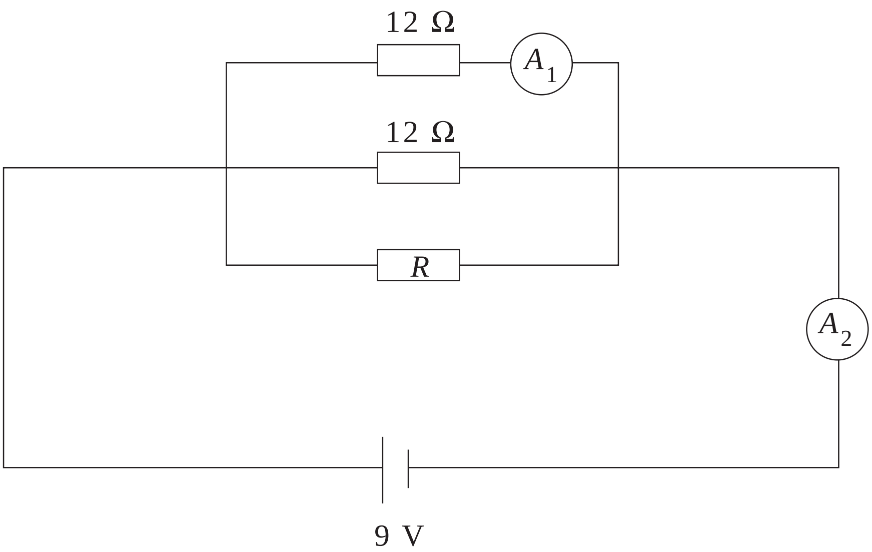
15. An electric train leaves Springwood (altitude 371 m) at 6.00 a.m. and completes the 31·0 km journey to Katoomba (altitude 1017 m) at 6.30 a.m. A railway car has a mass of $2{\cdot}00 \times 10^4$ kg. For this railway car, calculate:

(a) the gain in gravitational potential energy;

(b) the average power required by the electric motors.

16. (a) You are provided with three 12 ohm resistors. Draw a circuit diagram to show how they could be connected to produce an effective total resistance of 18 ohms.

(b) Three resistors were set up in a circuit as shown.

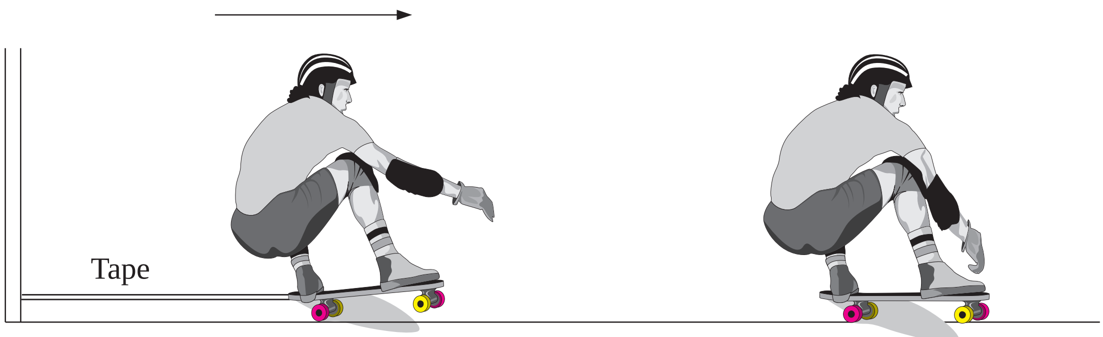


KEY
$A_1 = 0{\cdot}75$ A
$A_2 = 4{\cdot}5$ A

Calculate the resistance of the unknown resistor, R.

17. Student X was riding a skateboard that had some ticker tape connected to it. The ticker timer had a frequency of 50 Hz. Student X collided with student Y who was stationary on another skateboard. After the collision, the two skateboarders moved together in the same direction.

Student X Student Y



Combined mass = 55 kg Combined mass = 68 kg

A section of the ticker timer record, drawn to scale, before the collision is shown.

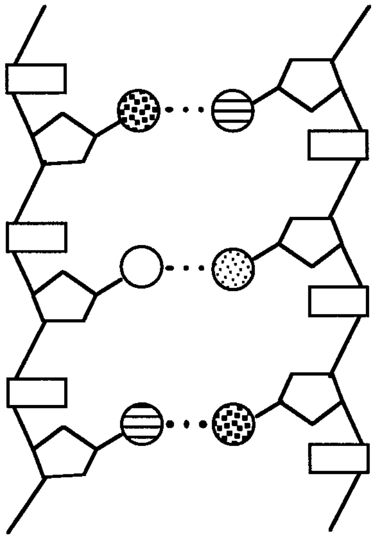
(a) Calculate the speed of:

(i) student X before the collision;

(ii) students X and Y immediately after the collision.

(b) Is this collision elastic or inelastic? Use calculations to support your answer.

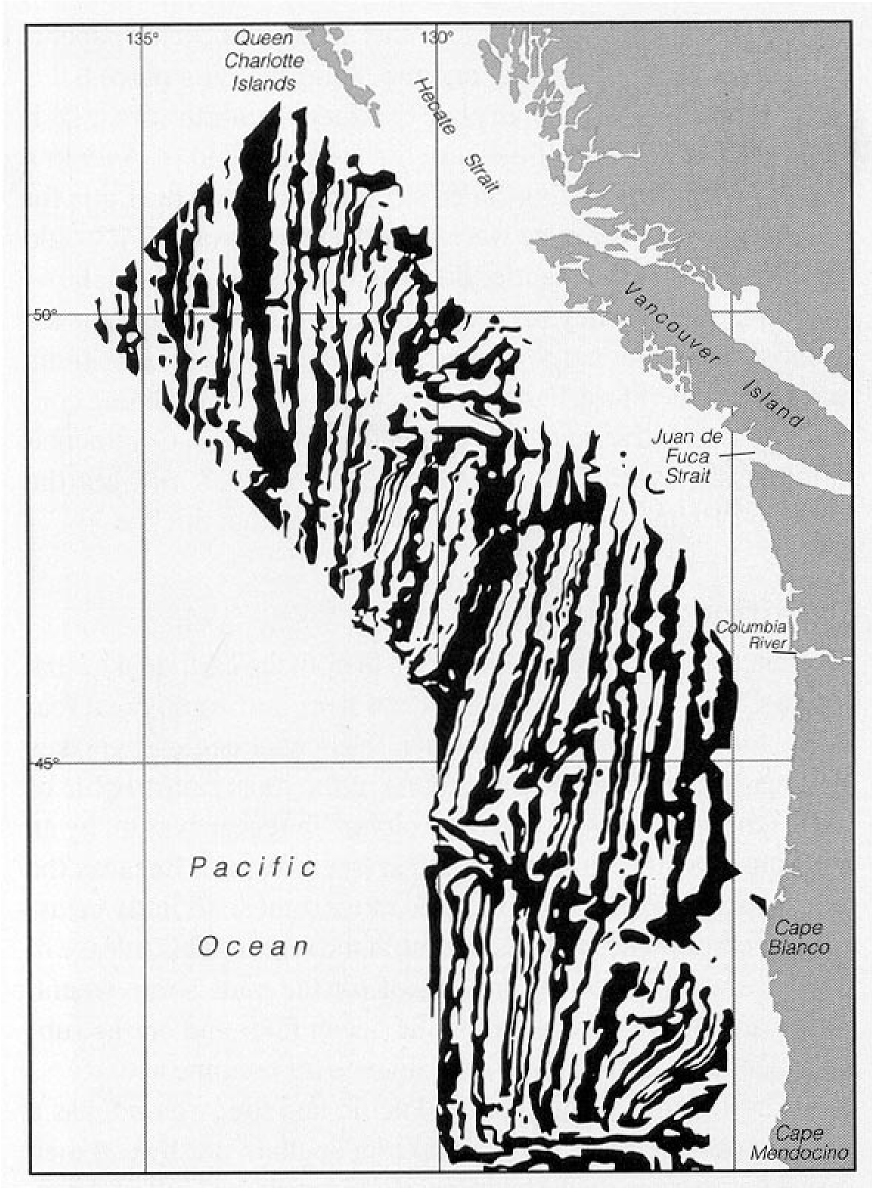
18. The schematic diagram shows part of a DNA molecule.



(a) State which feature of this molecule enables it to function as a store of genetic information.

(b) Describe TWO features of the molecule that allow it to transmit exactly the same information to two daughter cells resulting from mitosis.

19. The map below illustrates the striped pattern of magnetic anomalies preserved in the sea floor off the west coast of North America.



(a) Describe how sea-floor rocks become magnetised.

(b) Describe what such striped patterns indicate about:

(i) Earth's magnetic field over time;

(ii) the age of the ocean floors.

20. (a) Multicellular plants and multicellular animals possess differentiated cells with special features. These features are directly related to the function of the cell.

(i) Name TWO differentiated cell types from multicellular plants or multicellular animals.

(ii) List the function of each cell type.

(iii) List a specialised feature of each cell type.

(b) Name the tissue involved in photosynthesis in the leaf of a flowering plant.

(c) In plants, growth may vary with the seasons. Explain why cell growth often occurs more rapidly at warmer times of the year.

SECTION III

Attempt ALL questions.

Questions 21–28 are worth 5 marks each.

Answer this Section in the Section III Answer Book.

Show all necessary working in questions involving calculations.

Marks may be awarded for relevant working.

21. Some properties of four substances are shown in the table.

Substance	*m.p.* (°C)	*b.p.* (°C)	*Electrical conductivity*		
			solid	liquid	aqueous solution
A	113	445	low	low	—
B	1455	2730	high	high	—
C	801	1465	low	high	yes
D	–114	–85	low	low	yes

(a) Describe the structure and bonding for substances *A*, *B*, and *C*. Use the information from the table to support your answer.

(b) Explain why substance *D* conducts electricity only in aqueous solution, and not in the solid or liquid state.

22. There are many oxidation–reduction reactions where one species acts as the *oxidant* and another as the *reductant*.

(a) Define the term *reductant*.

(b) (i) Using the list of Standard Potentials on the Data Sheet, write the formula of:

1. a substance that can readily act as a reductant;
2. another substance that will react with the reductant you have chosen.

(ii) Write the overall equation to represent this reaction.

(c) Which substance from the list of Standard Potentials would most readily be reduced? Explain your answer.

(d) Briefly explain why potassium is not found in its elemental form in nature.

23. A chemical substance with molecular formula C_6H_{12} can be a member of two different homologous series.

(a) Define the term *homologous series*.

(b) Complete the table in the Section III Answer Book.

24. A toaster was tested in a laboratory. Its voltage and current were measured and recorded as shown in the table.

Voltage (V)	*Current* (A)
50	1·0
100	1·9
150	3·2
200	4·0

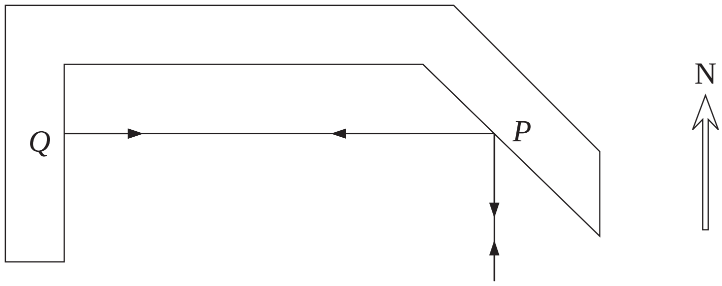
(a) Draw a labelled graph showing the relationship between voltage and current.

(b) Using the graph drawn in part (a), calculate the resistance of the toaster.

(c) Calculate the power output of the toaster when it is connected to a 240 V supply.

(d) The toaster is left on for two minutes at 240 V. Calculate the amount of charge that flows during this time.

25. An object of mass 0·100 kg is travelling 10·0 m s^{-1} north, when it strikes a wall at *P*. It then strikes the wall at *Q*, rebounds, and returns along its original path. Its speed remains at 10·0 m s^{-1} after each collision.



(a) Calculate the change in momentum of the object after its collision at *Q*.

(b) Calculate the overall change in momentum of the object as a result of the three collisions.

(c) Calculate the total amount of work done by the wall in the three collisions. Explain your answer.

(d) Explain how the collision of the object on the wall at *Q* obeys Newton's Third Law.

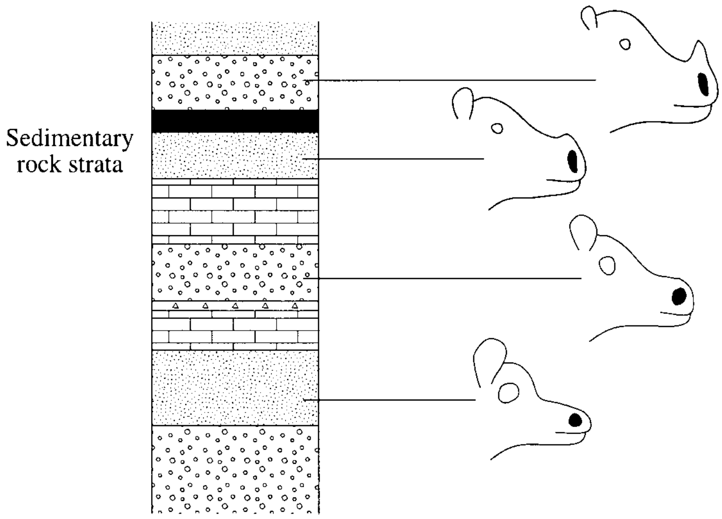
26. (a) Define the term *index fossil*.

(b) (i) Give TWO reasons why the fossil record does NOT contain examples of all organisms that have lived.

(ii) Explain the impact of this with regard to evolutionary theory.

(c) Describe the evidence that indicates when life first appeared on Earth.

27. Reconstructions from a set of hypothetical fossils are shown.

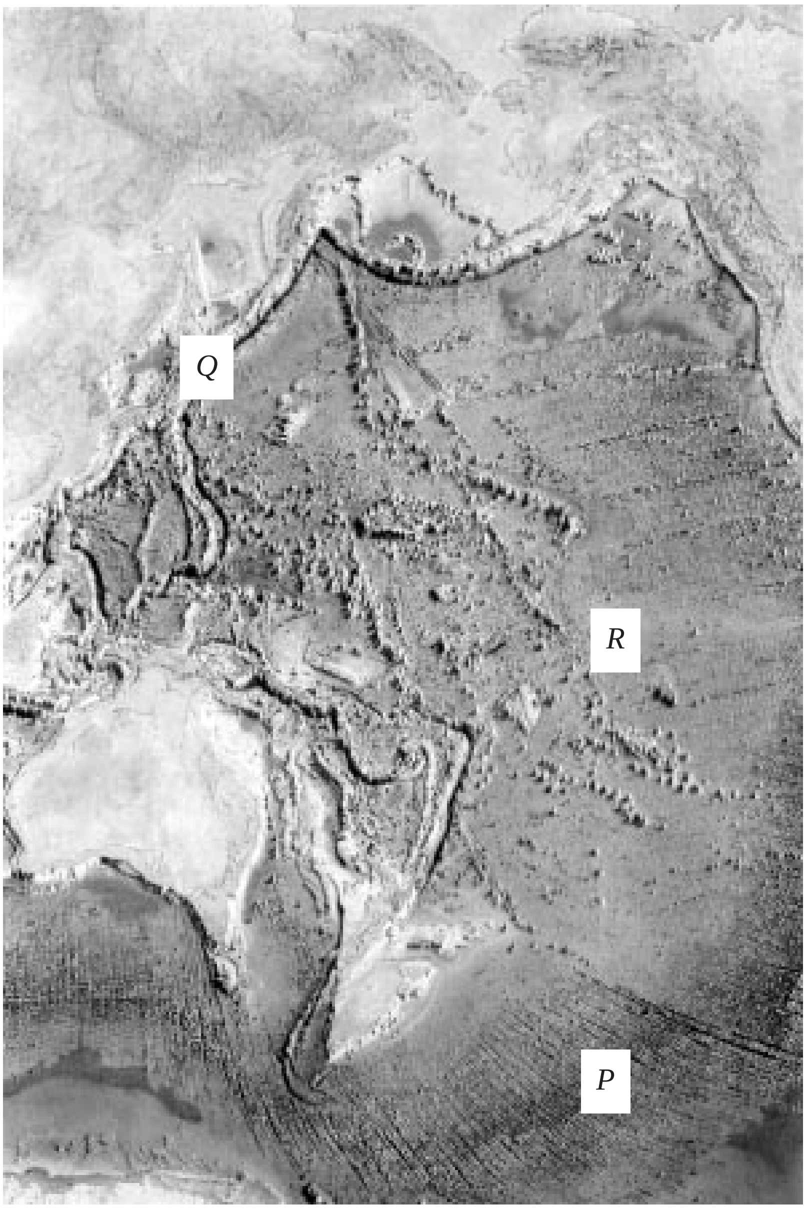


(a) Describe THREE apparent changes in these animals over time.

(b) Use the principle of natural selection to explain how ONE of these changes may have occurred.

(c) Describe how this sequence of fossils and sedimentary rock strata could be used to establish a timescale over a large region.

28. The following map of the Pacific Ocean floor reveals three principal topographic features: elongated mountain ranges (*P*), deep ocean trenches (*Q*), and broad flat abyssal plains (*R*).



(a) What is the name given to the elongated mountain ranges (*P*)?

(b) Explain the origin of each of the topographic features (*P*, *Q*, and *R*) with reference to the Plate Tectonic Theory. Use simple sketches to illustrate your answer.

(c) Describe the nature of earthquakes and volcanoes that are associated with the formation of the deep ocean trenches (*Q*).

SECTION IV

Attempt ALL questions.

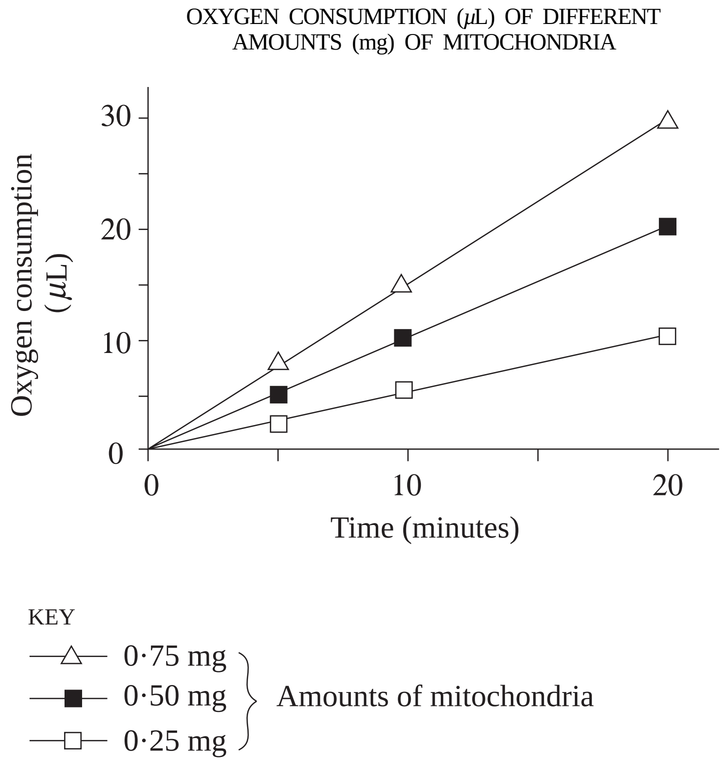
Questions 29–30 are worth 10 marks each.

Answer this Section in the Section IV Answer Book.

Show all necessary working in questions involving calculations.

Marks may be awarded for relevant working.

29. (a) A science teacher was performing experiments to measure respiration rates of mitochondria. Varying amounts of mitochondria were added to a medium and the oxygen consumption was recorded during the experiment.



(i) For a fixed amount of mitochondria, is the rate of oxygen consumption constant over the test period? Using the graph, justify your answer.

(ii) Describe the relationship between the amount of mitochondria and rate of oxygen consumption.

(iii) Identify TWO factors that would need to be controlled in this experiment.

(iv) State ONE alternative to oxygen consumption that could be used as a measure of respiration rate.

29. (Continued)

(b) A student investigated the physical properties of skeletal muscle from a cane toad. The student isolated a muscle and stimulated it electrically. The student was aware that isolated muscles display the same biochemical processes as muscles in living organisms. The stimulated muscle contracted and lifted a mass of 1·50 kg through a height of 5·00 mm in 370 ms.

(i) For this muscle, calculate the:

1. average force applied;

2. work done;

3. power output.

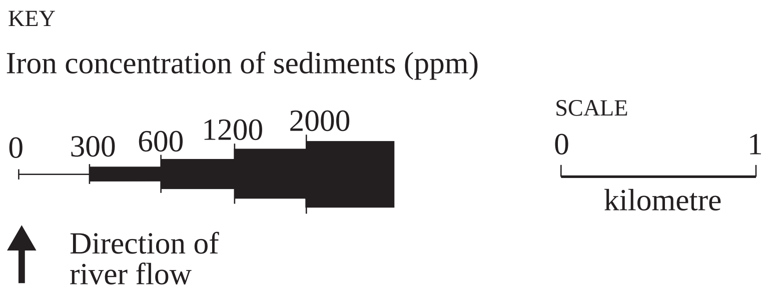
(ii) When this muscle was connected to a smaller mass, the rate of contraction increased. Explain why this occurred.

(iii) When the experiment was repeated regularly, the performance of the muscle decreased. Explain why this occurred.

30. The map below shows an area that is rich in ores containing iron, formed from hydrothermal processes. The primary iron ore minerals are contained in quartz veins. Pyrite (FeS_2) is one of the primary ore minerals.

Rainwater washing over the quartz veins has leached the primary ore minerals. Iron compounds have precipitated, forming sediments in rivers draining from this area. The iron concentration in the river sediments was analysed and the results are shown on the map.

MAP SHOWING A SURVEY OF IRON CONCENTRATION IN RIVER SEDIMENTS



(a) A known location of a primary ore deposit (D) is shown on the map.

On the map in your Section IV Answer Book, shade in the probable locations of TWO other primary ore deposits.

(b) Assume that in the hydrothermal process, elemental iron reacts only with hydrogen sulfide to form pyrite.

(i) Write the equation for this reaction.

(ii) Name the species that is being oxidised. Explain your choice.

30. (Continued)

In nature, pH and strength of oxidising/reducing environments determine which iron minerals precipitate. Diagram I shows the conditions under which various iron-containing minerals are stable.

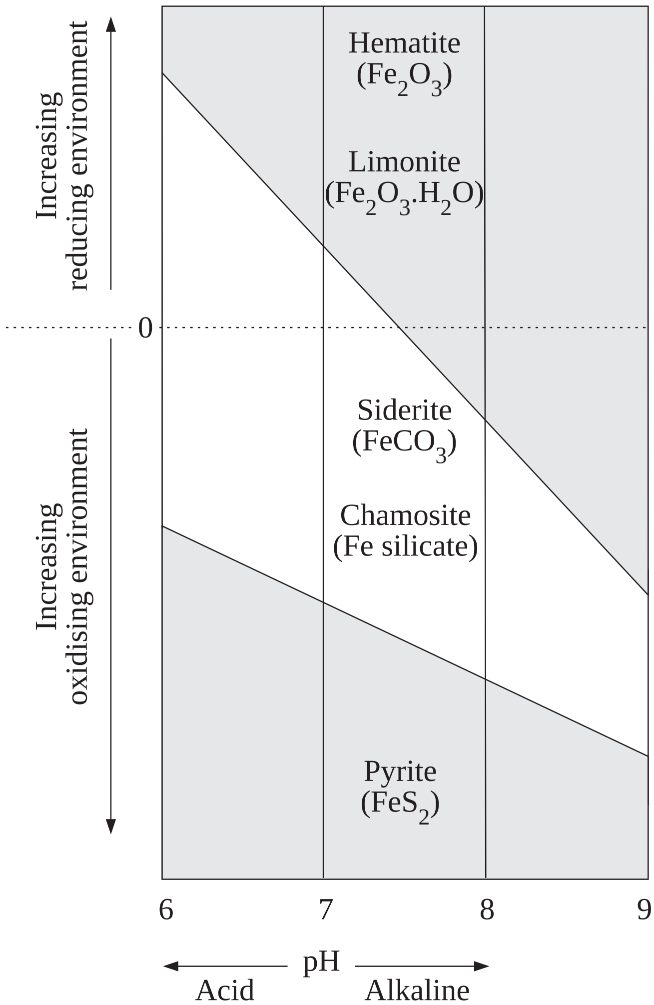


DIAGRAM I

30. (Continued)

The rivers draining out of the mapped region contain a high concentration of dissolved iron and flow into the sea. Three chemical environments in the sea are shown in Diagram II.

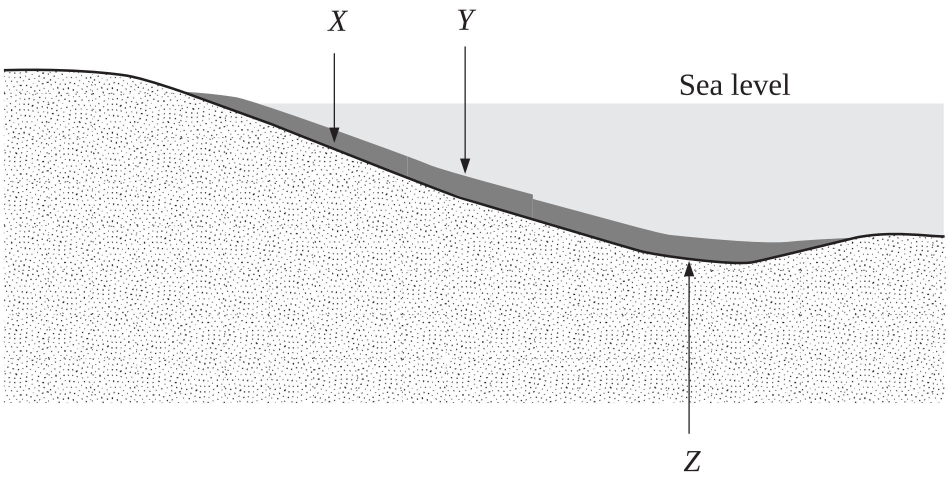


DIAGRAM II

X The water environment is oxidising and mildly alkaline near the shore.

Y The water is slightly reducing and mildly alkaline further from the shore.

Z The conditions are strongly reducing, and the water ranges from mildly acid to mildly alkaline in the deepest part of the ocean.

(c) Using information from Diagrams I and II, name an iron mineral that will be found at:

(i) *X*;

(ii) *Y*;

(iii) *Z*.

(d) Wastes from mines containing pyrite have sometimes been dumped into dams. The sulfide wastes react to produce a strongly acidic solution containing iron(III) oxide.

(i) Write the balanced equation for this reaction in the presence of oxygen.

(ii) Explain how seepage from such a dam could affect any surrounding agricultural area.

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DATA SHEET

Values of several numerical constants

Avogadro's constant, N_A	$6{\cdot}022 \times 10^{23}$ mol^{-1}
Elementary charge, e	$1{\cdot}602 \times 10^{-19}$ C
Faraday constant, F	96 490 C mol^{-1}
Gas constant, R	$8{\cdot}314$ J K^{-1} mol^{-1} $0{\cdot}0821$ 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, μ_0	$4\pi \times 10^{-7}$ N A^{-2}
Universal gravitation constant, G	$6{\cdot}7 \times 10^{-11}$ N m^2 kg^{-2}
Mass of Earth	$6{\cdot}0 \times 10^{24}$ kg
Radius of Earth	6378 km
Planck's constant, h	$6{\cdot}626 \times 10^{-34}$ J s
Density of water	$1{\cdot}00 \times 10^{3}$ kg m^{-3}
Specific heat capacity of water	$4{\cdot}18 \times 10^{3}$ J kg^{-1} K^{-1}
Speed of sound in air	340 m s^{-1}

Some Standard Potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2·94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2·91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2·87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2·71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2·36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1·68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1·18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_2(g) + OH^-$	–0·83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0·76 V
$S(s) + 2e^-$	$\rightleftharpoons$	S^{2-}	–0·57 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0·44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0·24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0·14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0·13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_2(g)$	0·00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0·16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0·34 V
$\frac{1}{2} O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0·40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0·52 V
$\frac{1}{2} I_2(s) + e^-$	$\rightleftharpoons$	I^-	0·54 V
$\frac{1}{2} I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0·62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0·77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0·80 V
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	0·96 V
$\frac{1}{2} Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1·08 V
$\frac{1}{2} Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1·10 V
$\frac{1}{2} O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1·23 V
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	1·36 V
$\frac{1}{2} Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1·36 V
$\frac{1}{2} Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1·40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1·51 V
$\frac{1}{2} F_2(g) + e^-$	$\rightleftharpoons$	F^-	2·89 V

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

PERIODIC TABLE

KEY

Atomic Number Atomic Mass	79 Au 197·0 Gold	Symbol of element 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.