BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1999
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. Complete your answers in either blue or black pen 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.

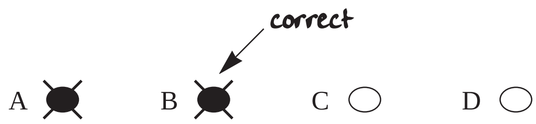
Instructions for answering multiple-choice questions

- Complete your answers in either blue or black pen.
- Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word *correct* and drawing an arrow as follows.



1 Which of the following compounds has a relative formula mass of 240·2?

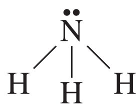
(A) $MgCl_2.6H_2O$

(B) $Na_2Cr_2O_7$

(C) Li_2SO_4

(D) K_3AsO_3

2 Which statement is true for the structures given?



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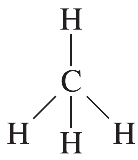


(A) NH_3 has a higher boiling point than CH_4 due to their different covalent bonds.

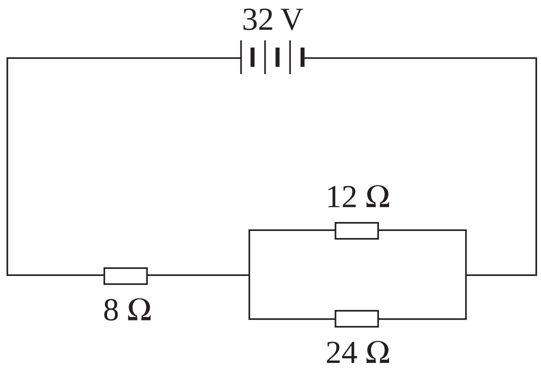
(B) NH_3 has a lower solubility in water than CH_4 due to its lone pair of electrons.

(C) NH_3 has a higher boiling point than CH_4 due principally to hydrogen bonding.

(D) CH_4 has a higher boiling point than NH_3 due to their different polarities.

Please turn over

3 Three resistors are connected as shown in the diagram.



Which of the following is a correct statement?

(A) The potential difference across the 12 Ω resistor is the same as that across the 24 Ω resistor.

(B) The rate of energy dissipation in the 12 Ω resistor is the same as that in the 24 Ω resistor.

(C) The current through the 12 Ω resistor is the same as that through the 24 Ω resistor.

(D) The current through the 12 Ω resistor is the same as that through the 8 Ω resistor.

4 The mass of a roller-coaster car and its passengers is 800 kg. When it is at the foot of a rising section of track, which has a height of 12 m, the car is travelling with a speed of 14 m s^{-1}. Which of the following is a correct statement about the car at its highest point on this section of the track? (Numerical values are given to two significant figures.)

(A) The car does not reach the top of the climb.

(B) The car's potential energy is 94 kJ.

(C) The car's kinetic energy is 78 kJ.

(D) The car's speed is 6·3 m s^{-1}.

5 Diagram *A* below shows a toy called Newton's Cradle. It consists of five steel balls of equal mass which are suspended by strings from the frame so that the balls just touch along the line of their diameters when they are at rest. When the balls are moved and collide, the collisions can be treated as elastic.

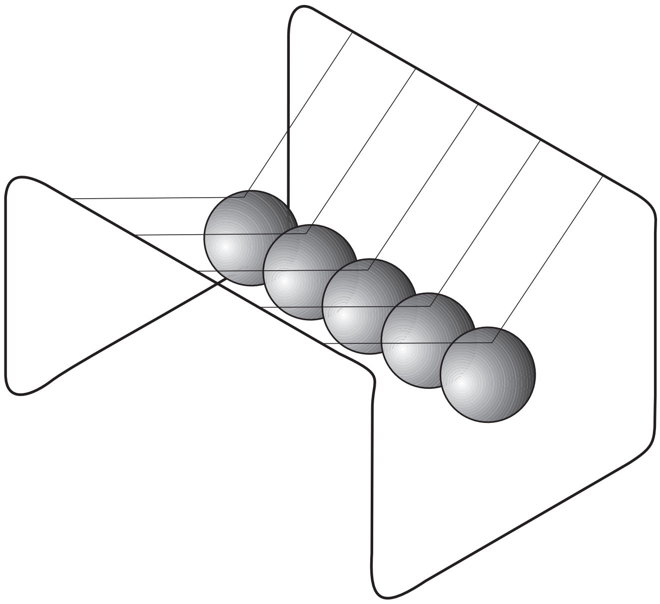


DIAGRAM *A*

Diagram *B* shows that the ball at one end has been displaced and is about to collide with the others which are at rest. At the instant before the collision, the moving ball has velocity $2v$. It is suggested that Diagram *C* shows the outcome of this collision, with two balls moving, each with velocity v.

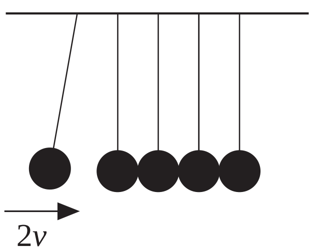


DIAGRAM *B*
VIEW FROM THE SIDE

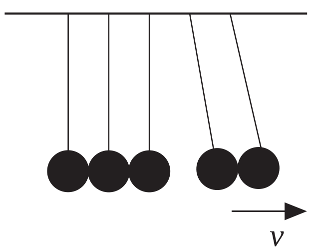


DIAGRAM *C*
VIEW FROM THE SIDE

The outcome shown in Diagram *C* is

(A) possible because both energy and momentum are conserved.

(B) possible because energy is conserved but momentum is not.

(C) impossible because neither momentum nor energy is conserved.

(D) impossible because momentum is conserved but energy is not.

6 An equation that indicates the overall process of respiration is given below.

$$\underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} \rightarrow \underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O}$$

In cells, respiration, as described above, involves

(A) only the Krebs cycle.

(B) the summation of anaerobic (glycolysis) and aerobic (Krebs cycle) metabolic processes.

(C) a sequence of metabolic reactions that convert proteins and lipids to sugar.

(D) the burning of sugar and is essentially the reverse of photosynthesis.

7 Pyrite (FeS_2) oxidises via the reaction:

$$2FeS_2(s) + 7O_2(g) + 2H_2O(l) \rightarrow 2Fe^{2+}(aq) + 4SO_4^{2-}(aq) + 4H^+(aq).$$

What quantity of iron(II) sulfate can be produced by the oxidation of 60·0 g of pyrite?

(A) 38·0 g

(B) 76·0 g

(C) 124 g

(D) 152 g

8 In the following reaction

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

(A) zinc is oxidised and the copper ions act as oxidants.

(B) zinc is reduced and the copper ions act as oxidants.

(C) zinc is oxidised and the copper ions act as reductants.

(D) zinc is reduced and the copper ions act as reductants.

9 The Appalachian Mountains in the United States of America are an eroded fold mountain range. Geological structures in this range include tight folds, thrusts and other evidence of deformation.

These mountains were most likely formed at the site of

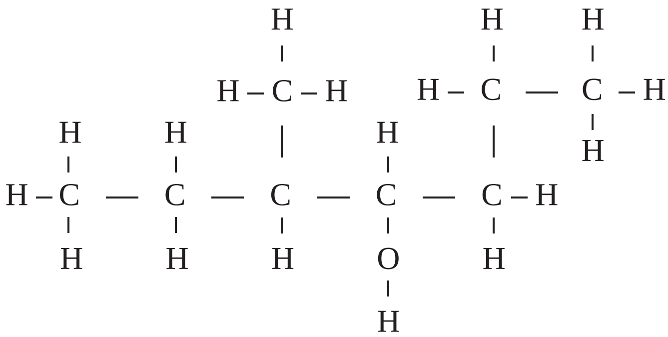
(A) strike-slip faulting along a transform fault.

(B) continent–continent plate convergence.

(C) plate divergence at a mid-ocean ridge.

(D) ocean–ocean plate convergence.

10



The IUPAC nomenclature for the compound shown above is

(A) 3,5,5-trimethyl-4-pentanol.

(B) 1,1,3-trimethyl-2-pentanol.

(C) 3-methyl-4-heptanol.

(D) 5-methyl-4-heptanol.

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SECTION II

Attempt ALL questions.

Questions 11–20 are worth 3 marks each.

Answer these questions in the Section II Answer Book.

Show all necessary working in questions involving calculations.

Marks may be awarded for relevant working.

11 An unknown organic compound was found to contain 69·8 g carbon, 11·6 g hydrogen and 18·6 g oxygen only. The relative molar mass was determined to be 172 g.

(a) Calculate the empirical formula of the unknown organic compound. Show your working.

(b) Find the molecular formula of the compound. Show your working.

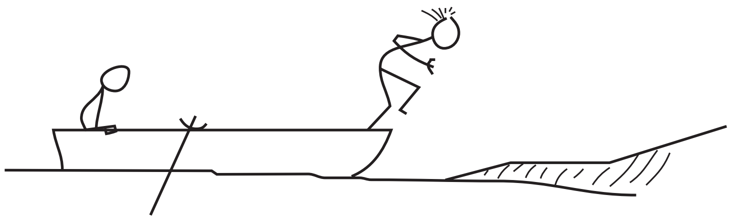
12 25·0 mL of a sodium hydrogen carbonate solution was titrated with 19·6 mL of a nitric acid solution of unknown concentration. 100 mL of the sodium hydrogen carbonate solution is known to contain 0·740 g of solute.

(a) Write a balanced chemical equation to describe the reaction of nitric acid with sodium hydrogen carbonate.

(b) Calculate the concentration of the sodium hydrogen carbonate solution in mol L^{-1}.

(c) Calculate the concentration of the nitric acid solution in mol L^{-1}.

13 A rowing boat of mass 120 kg has a child of mass 40 kg sitting at the back of the boat, and an adult of mass 80 kg standing at the front. The boat is at rest close to a river bank.



The adult jumps off the boat with a horizontal velocity of 10 m s^{-1} towards the bank.

(a) Assume that the water causes no frictional resistance. Explain clearly, in terms of Newton's laws, what happens to the boat and the adult as the adult jumps off the boat.

(b) Calculate the recoil velocity of the boat.

14 A horse is dragging a cart along a muddy, straight, horizontal road. At the start of a section of this road, which is 250 m long, the speed of the cart is 2·8 m s^{-1} and at the end of the section the speed has increased to 5·0 m s^{-1}. The mass of the cart is 3100 kg and the horse exerts a steady force of 1200 N on the cart all the time.

(a) What is the work done by the horse on the cart as it moves along the 250 m section of road?

(b) What is the change in kinetic energy of the cart?

(c) What is the force of friction exerted by the mud on the cart? Show your working.

15 When connected to a mains supply of 240 V, a 100-watt globe glows more brightly than a 60-watt globe. Explain:

(a) which globe would have the higher resistance;

(b) which globe would draw the larger current when connected to the mains;

(c) which globe would glow more brightly if they were connected in series to the mains.

16 In the study of acid/base reactions, you were presented with information concerning the behaviour of oxides with water.

(a) Write the equation for the reaction of liquid water with each of:

(i) $Na_2O(s)$;

(ii) $P_4O_{10}(s)$.

(b) Qualitatively compare the pH of the solution produced in part (a) (i) with that produced in part (a) (ii) above.

17 The diagram below shows three species (*A*, *B* and *C*) of a fossil group, with their age ranges in millions of years (Ma) before the present. These fossils are commonly used as index fossils.

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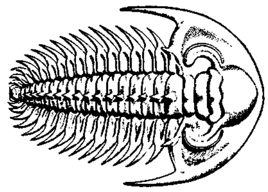

A	*B*	*C*
570 – 440 Ma	480 – 345 Ma	570 – 520 Ma

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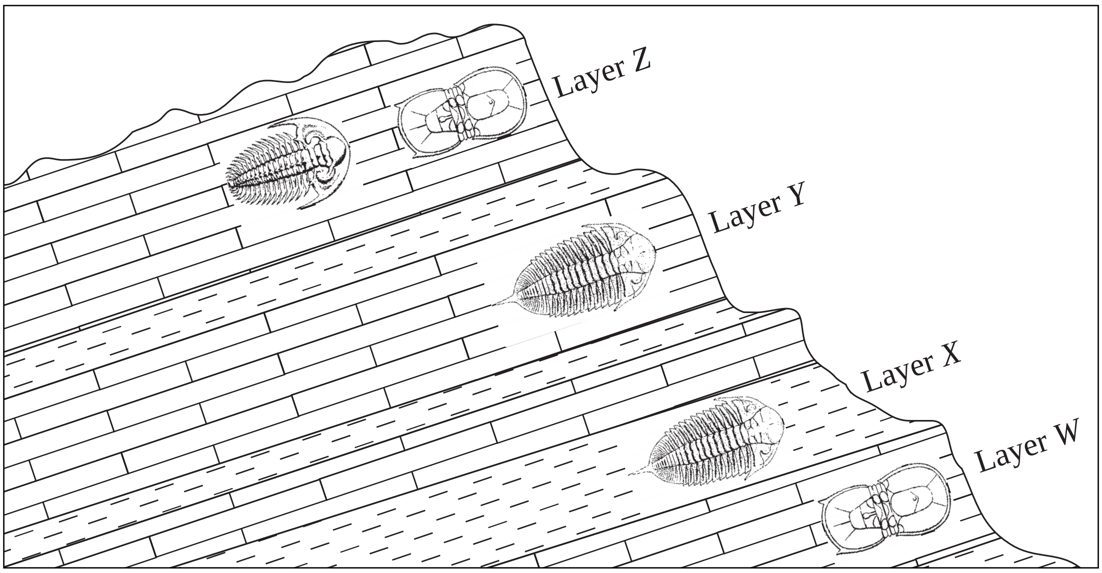
These fossils occur in rock layers (*W*, *X*, *Y* and *Z*) exposed in a road cutting as shown below.



(a) State TWO features that make a fossil useful as an index fossil.

(b) State the possible age range for layer *Z*.

(c) Explain why this arrangement of rock layers apparently contradicts the Principle of Superposition.

18 The melting points and electrical conductivities of the oxides of four elements from period 3 are given in the table below. The electrical conductivities are given for the oxides as solids and when they have been melted.

Period 3 element	*Melting point of oxide* (°C)	*Electrical conductivity of oxide as a solid*	*Electrical conductivity of oxide as a melt*
W	1713	Nil	Nil
X	–75	Nil	Nil
Y	1132	Nil	High
Z	2852	Nil	High

(a) Name the type of bonding that would exist for the oxide of:

(i) *W*;

(ii) *Z*.

Give a reason for each of your answers.

(b) Explain why the oxide of *X* has such a low melting point.

19 20 g of anhydrous solid Na_2SO_3 was accidentally dropped into 100 mL of 2 mol L^{-1} H_2SO_4 solution at 298 K and 101·3 kPa. A poisonous gas, SO_2, and water were two of the three products.

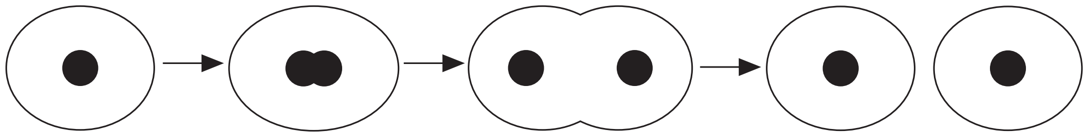
(a) Write the equation for the reaction.

(b) Determine which reactant was in excess.

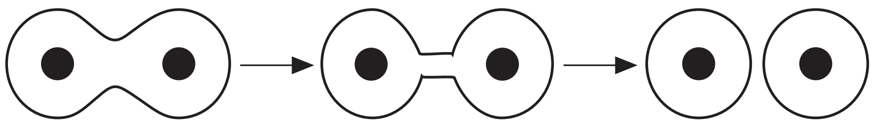
(c) Calculate the volume of gas produced.

20 Diagrams *A* and *C* represent different processes in living organisms, and diagram *B* represents a stage in a process.

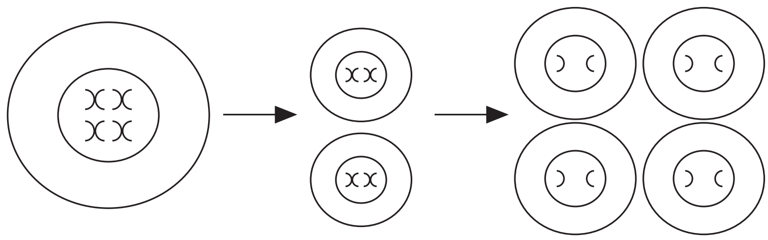
A



B



C



(a) Name the processes *A* and *C* and the stage *B*.

(b) Which process above produces gametes? Explain your answer.

SECTION III

Attempt ALL questions.

Questions 21–28 are worth 5 marks each.

Answer these questions in the Section III Answer Book.

Show all necessary working in questions involving calculations.

Marks may be awarded for relevant working.

21 Use the diagrams below to answer the following questions.

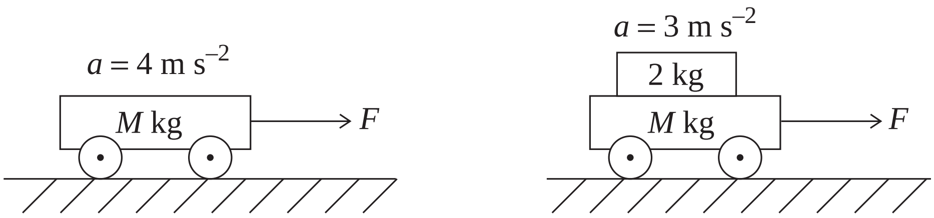


DIAGRAM *A* DIAGRAM *B*

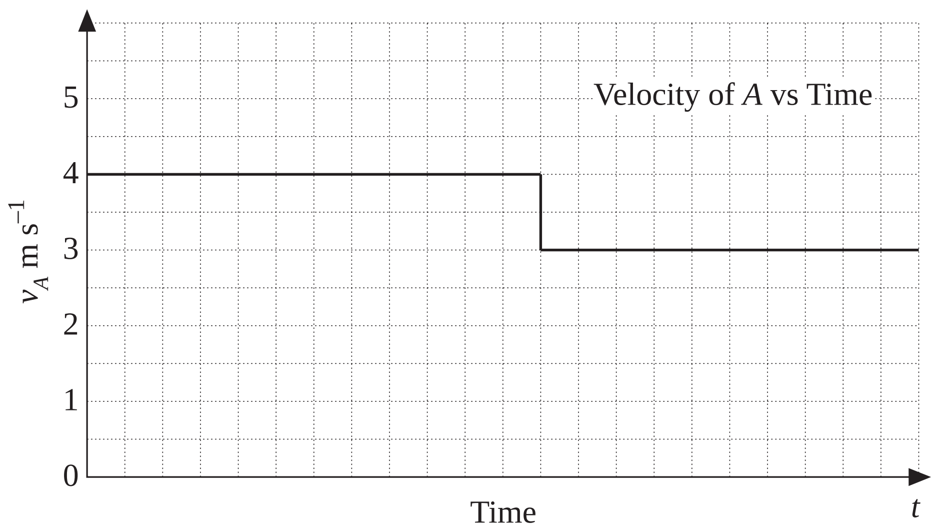
A student applies a constant force of F N to a trolley of mass M kg and measures the acceleration to be 4 m s^{-2}, as shown in Diagram *A*. When a 2 kg mass is placed onto the trolley the same force results in an acceleration of 3 m s^{-2}, as shown in Diagram *B*.

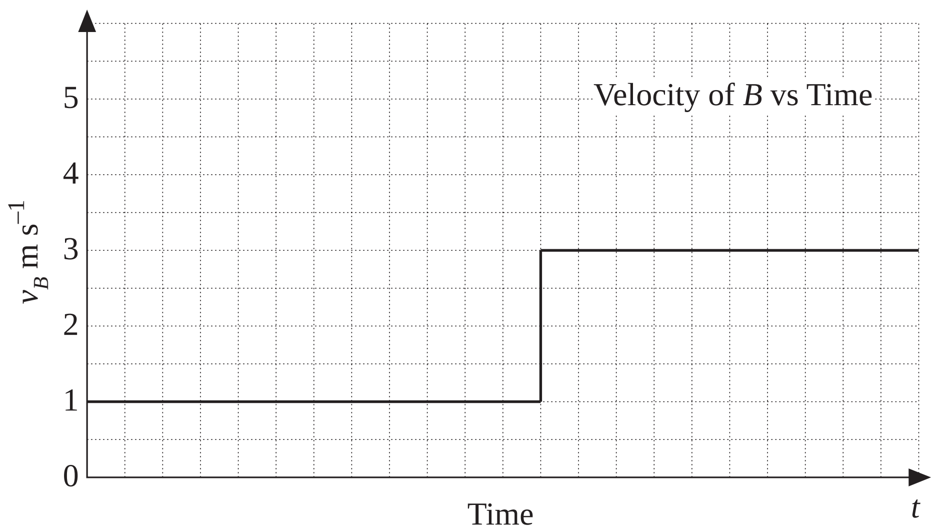
(a) Determine the magnitude of the force F.

(b) The trolley and 2 kg mass start from rest. Use your understanding of work and energy to calculate the distance through which they move during the first 0·75 seconds of their motion.

(c) The applied force was supplied by a falling 3·53 kg mass attached to the trolley via a string over a pulley. The string is light and inextensible and the pulley is frictionless. Calculate the change in the gravitational potential energy of the 3·53 kg mass in the 0·75 seconds interval in part (b). Explain where that change in energy goes.

22 Two balls are rolling along the same straight line on a horizontal surface and collide. Ball A has a mass of 4·00 kg and ball B has a mass of 2·00 kg. The velocity–time graphs for each ball are shown below.





(a) Draw clear sketches that show:

(i) the motion of the balls before the collision;

(ii) the motion of the balls after the collision.

(b) Show that momentum is conserved in this collision.

(c) Calculate the total kinetic energy before the collision and after the collision. State whether or not the collision is elastic.

23 This question refers to the diagrams below.

Diagram *A* shows the time scale for magnetic reversals on the Earth over the last five million years. Diagram *B* shows the magnetic anomaly pattern from an oceanographic survey over part of the Indian Ocean.

Diagram *C* shows the ocean depths between points *X* and *Y* marked on Diagram *B*.

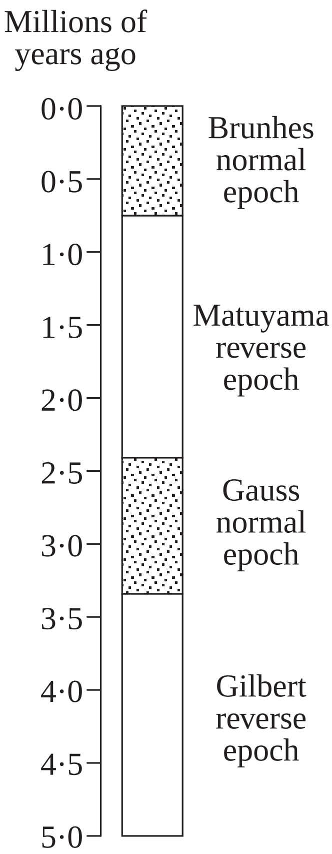


DIAGRAM *A*

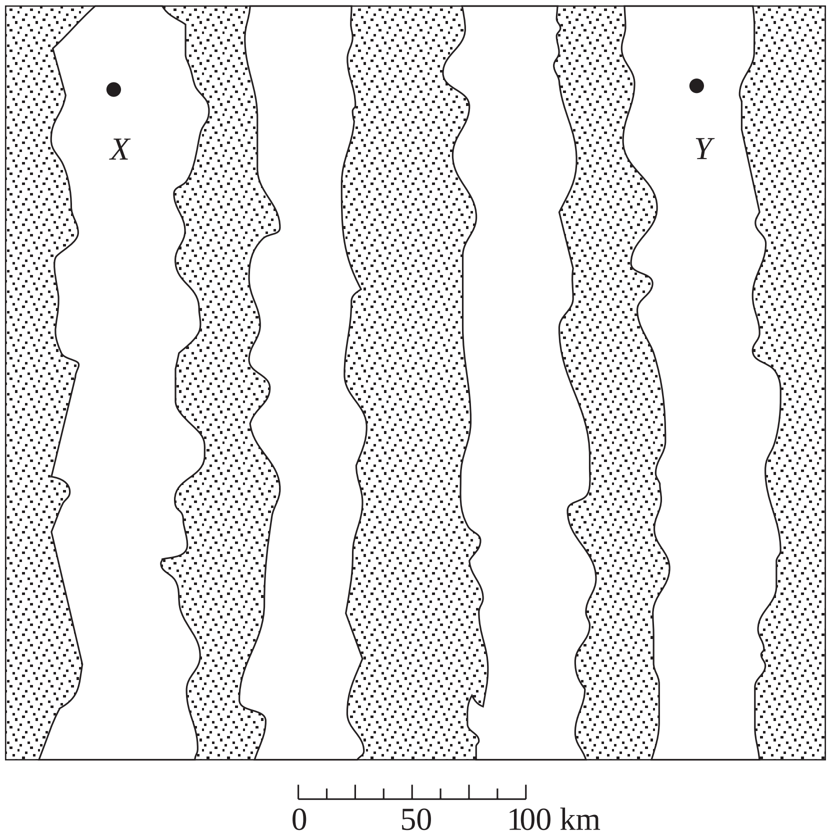


DIAGRAM *B*

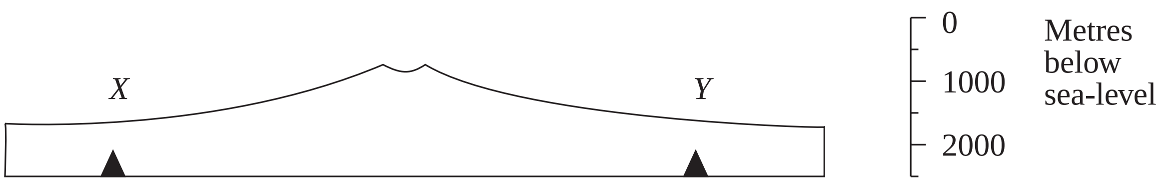


DIAGRAM *C*

(a) (i) What is the rate of movement of point *X* relative to point *Y*? Express your answer in cm year^{-1}.

(ii) Why does the ocean depth increase away from the centre of the profile in Diagram *C*?

(b) What is the role of the asthenosphere in plate tectonic theory?

(c) Describe in detail TWO types of evidence for partial melting in the asthenosphere.

24 $C_4H_{10}O$ can exist in a number of isomeric forms. A primary alcohol of $C_4H_{10}O$ is easily oxidised.

(a) Give the name and structural formula of a primary alcohol of $C_4H_{10}O$.

(b) Give the name and structural formula of the organic product produced by the complete oxidation of the primary alcohol $C_4H_{10}O$ that you have named in part (a).

(c) Name a common oxidising agent used for the reaction in part (b).

(d) Name and give the structural formula of a secondary alcohol of formula $C_4H_{10}O$.

25 A student bubbled 200 mL of hydrogen sulfide gas into 100 mL of a silver nitrate solution. All the silver ions in the solution were precipitated as solid silver sulfide by the hydrogen sulfide, and 102 mL of gas remained unreacted. The volume of the hydrogen sulfide gas was measured at 298 K and 101·3 kPa.

(a) Write a balanced chemical equation to describe the reaction between silver nitrate and hydrogen sulfide. (Show the states for all reactants and products.)

(b) Calculate the number of moles of hydrogen sulfide that reacted with the silver ions.

(c) Determine the concentration of the silver nitrate solution.

(d) Determine the mass of silver sulfide precipitated.

26 (a) (i) Name the molecules that are the building blocks of proteins.

(ii) What is the name given to the covalent bond between these building blocks in proteins?

(b) What is the role of the nucleus in the synthesis of proteins in the cell?

(c) Where in the cell does protein synthesis occur?

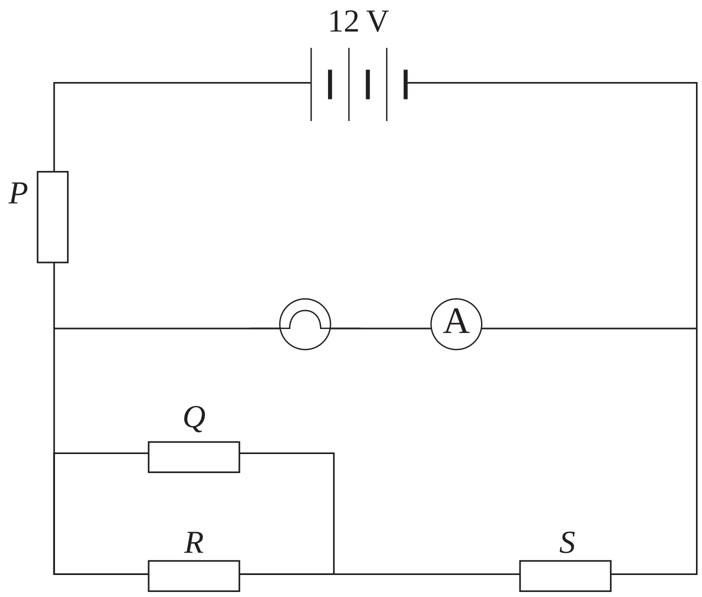
(d) Describe ONE function of proteins in cells.

27 (a) Use a diagram to show why a water molecule is polar.

(b) Explain why methanol is more soluble than 1-octanol in water.

(c) Explain why hydrogen sulfide has a different physical state from water at 298 K and 101·3 kPa.

28 Consider the circuit diagram below.



The resistors and globe all have a resistance of 2 ohms and the ammeter is ideal.

(a) Calculate the total current drawn from the power supply.

(b) What would be the reading on the ammeter?

(c) How much energy would be dissipated by the resistor labelled *S* in a one-minute period?

SECTION IV

Attempt ALL questions.

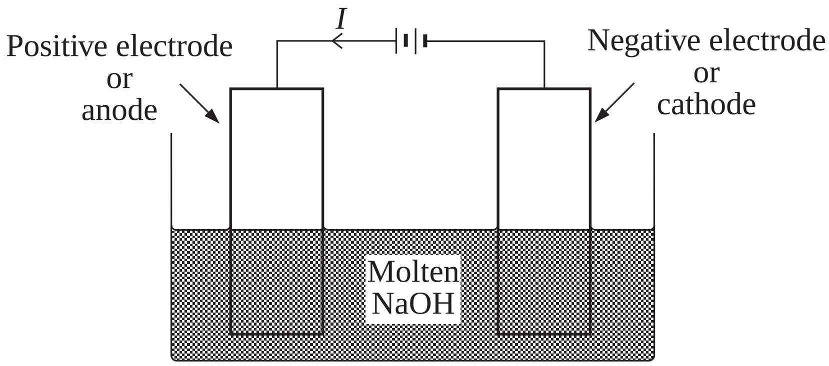
Questions 29 and 30 are worth 10 marks each.

Answer these questions in the Section IV Answer Book.

Show all necessary working in questions involving calculations.

Marks may be awarded for relevant working.

29 The element sodium was isolated in 1807 by Sir Humphrey Davy using the electrolysis of molten sodium hydroxide. A schematic diagram of the apparatus is shown below.



During the process, sodium is produced at the cathode, and both oxygen and water are produced at the anode. The sodium which was produced was protected from any further reaction.

Some properties of Na and NaOH are given in the table below.

Material	*Atomic/molecular mass*	*Melting point* (°C)	*Density* (kg m^{-3})
Na	23	98	$0{\cdot}97 \times 10^3$
NaOH	40	323	$2{\cdot}13 \times 10^3$

(a) Explain why it is necessary to use molten NaOH rather than solid NaOH.

(b) (i) Write the half-equation for the production of sodium.

(ii) State whether the sodium will be found on the surface or at the bottom of the molten NaOH. Explain your answer.

(c) (i) Write the half-equation for the process at the anode.

(ii) Is this process oxidation or reduction? Explain your answer.

(iii) What will happen to the water which is produced?

(d) A current of 12 A flowed through the apparatus for two hours. If all the sodium produced had been collected, calculate the mass of sodium metal collected.

30 (a) The age ranges for strata within a sedimentary rock sequence have been established using various marine fossils. The stratigraphic sequence and locations of the fossils collected are indicated in Diagram *X*.

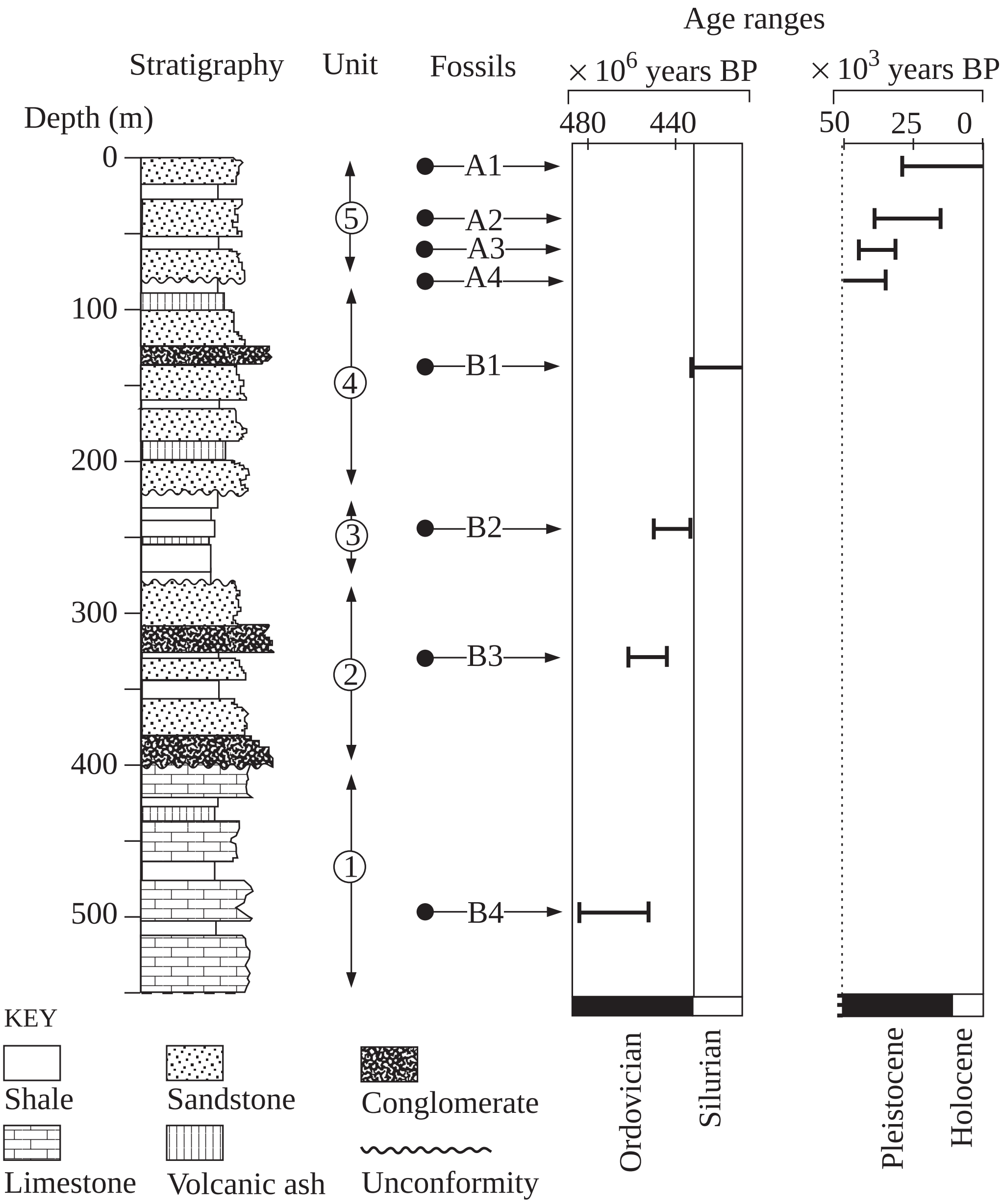


DIAGRAM *X*

To refine the ages of the key geological events in this sequence, a geologist has decided to use radiometric dating.

Isotope pair	*Half-life* (years)
$^{87}Rb \rightarrow {}^{87}Sr$	$4{\cdot}7 \times 10^{10}$
$^{14}C \rightarrow {}^{14}N$	$5{\cdot}730 \times 10^{3}$
$^{40}K \rightarrow {}^{40}Ar$	$1{\cdot}3 \times 10^{9}$

DIAGRAM *Y*

QUESTION 30 (Continued)

The volcanic ash layers have abundant feldspar, containing Rb, K and Na, and mica, containing K, Fe and Mg. Sedimentary rocks within the upper 200 m of the sequence contain thin layers of organic-derived carbon.

(i) Explain which pair or pairs of isotopes in Diagram *Y* would be most suitable for age dating the complete stratigraphic sequence in Diagram *X*.

(ii) In what type of geological environment would the rocks of unit ① have been deposited?

(iii) In Diagram *X* there is an indication of a major break in the fossil record. Explain how such a break might have occurred.

(b) In Diagram *Z*, fossils from Group B, Order *Graptoloidea*, are drawn to the same scale. Graptolites are a multi-organism colony with individual organisms housed in thecae. The thecae join together along the stipes and the stipes attach to each other via the stem.

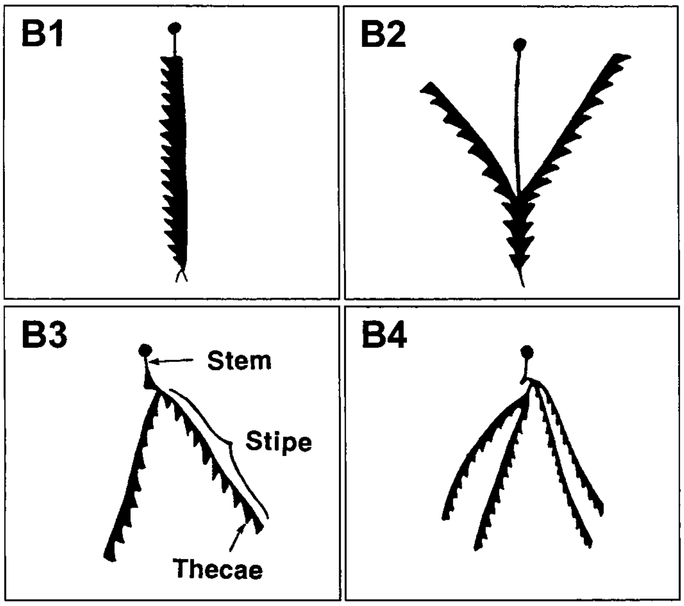


DIAGRAM *Z*

With reference to the stratigraphy in Diagram *X*, identify TWO apparent evolutionary changes in this fossil group.

(c) Charles Darwin observed the diversity of species on the Galapagos Islands. He proposed a mechanism for the process that brought about this diversity. Using any example, explain this mechanism.

(d) Many theories have been proposed for the origin of life on Earth. However, only some of these have been supported with scientific evidence. Describe any ONE of these theories supported by scientific evidence. State the scientific evidence that supports it.

End of Paper 1

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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} $0{\cdot}0821$ 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	$4\pi \times 10^{-7}$ 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

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

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.