BOARD OF STUDIES
NEW SOUTH WALES

HIGHER SCHOOL CERTIFICATE EXAMINATION

1998
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 blue or black pen, or 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.

Complete your answers in blue or black pen, or in pencil on the Answer Sheet provided.

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

1. The relative formula mass for the compound manganese(II) nitrate hexahydrate is

(A) 178·9 g

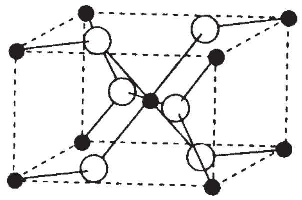
(B) 256·4 g

(C) 287·1 g

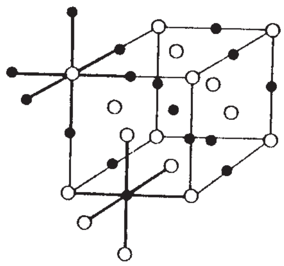
(D) 304·9 g

2. Which of the following diagrams best represents the ionic solid TiO_2?

(A)



(B)



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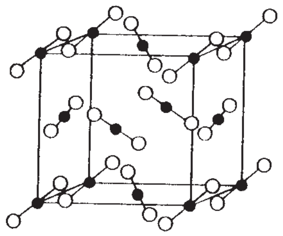

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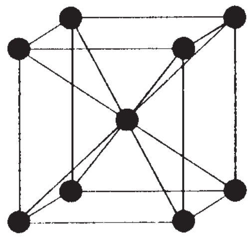


3. Which of these solutions has the lowest pH?

(A) 0·1 mol L^{-1} ethanol solution

(B) 0·1 mol L^{-1} hydrochloric acid solution

(C) 0·1 mol L^{-1} sodium hydroxide solution

(D) 0·1 mol L^{-1} sulfuric acid solution

4. The number of different mono-chlorinated isomers produced when butane reacts with chlorine is

(A) 1

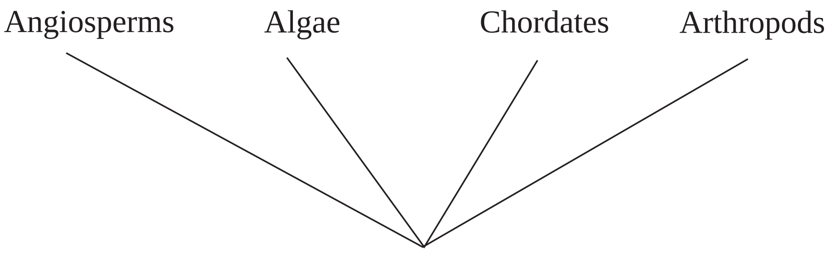
(B) 2

(C) 3

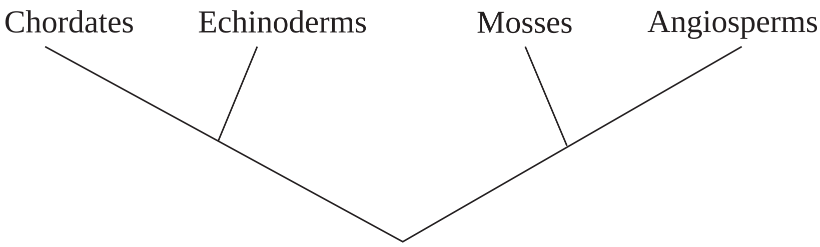
(D) 4

5. Which of the following diagrams best represents the evolutionary relationships of the life forms shown?

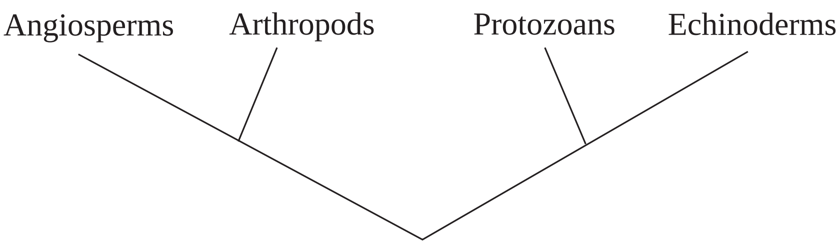
(A)



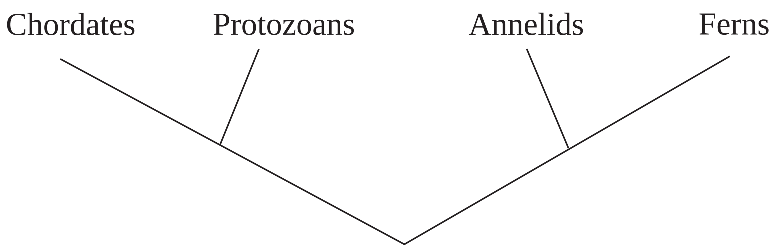
(B)



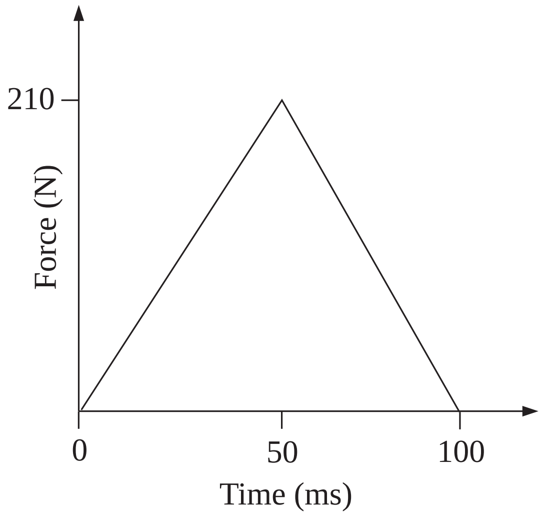
(C)



(D)



6. The graph shows the magnitude of the force acting on a hockey ball of mass 175 g when it collides with and rebounds from a goal post. The ball has a speed of 30·0 m s^{-1} immediately before and after the collision.



The change in momentum of the ball is

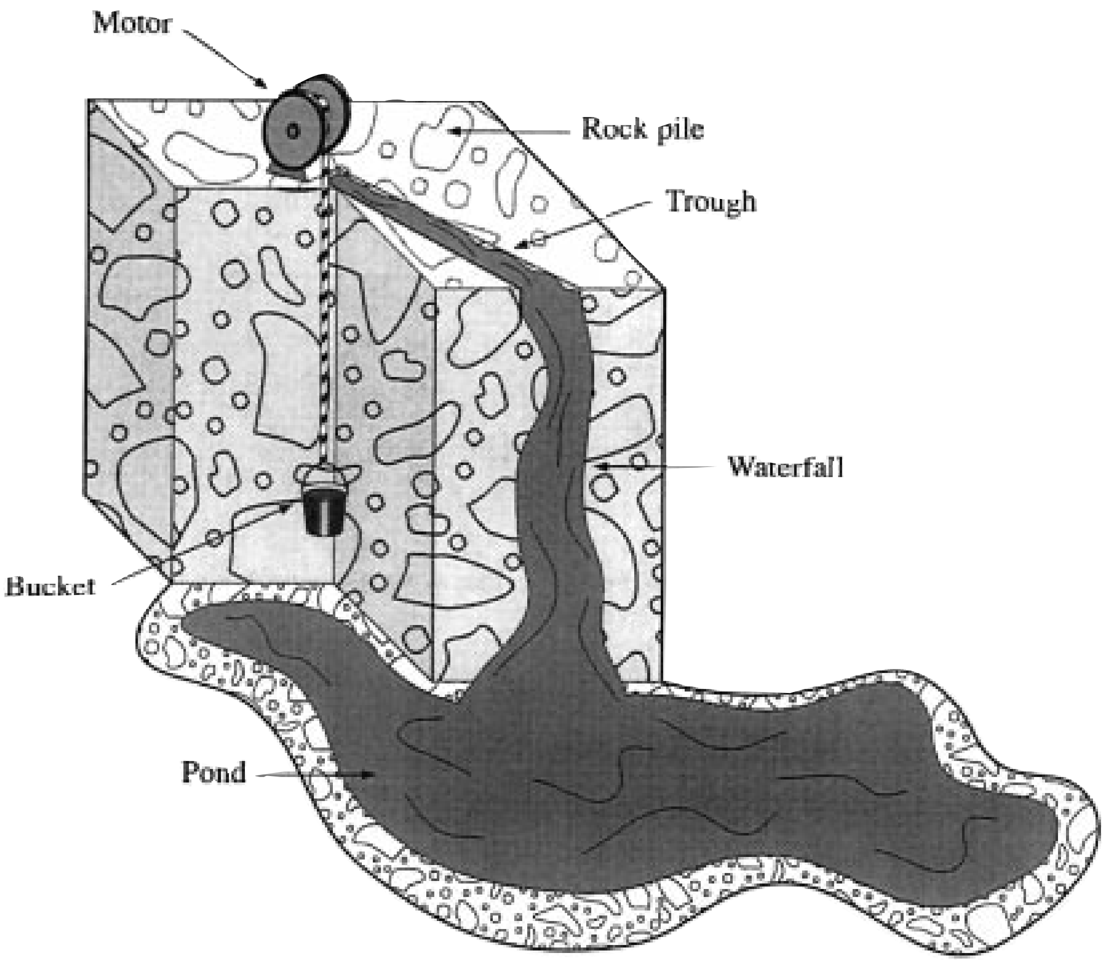
(A) 0 N s

(B) 5·25 N s

(C) 10·5 N s

(D) 21·0 N s

7. A garden waterfall has a motor that raises a bucket of water from a pond to the top of a rock pile where the bucket is emptied into a horizontal trough. The water flows along the trough, then tumbles down the rocks back to the pond.



The velocity of the water as it enters the pond is related to

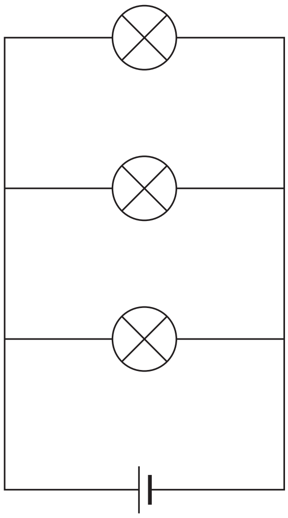
(A) the power of the motor.

(B) the volume of the bucket.

(C) the height of the rock pile.

(D) the length of the horizontal trough.

8. A circuit containing three lights is shown below. The light bulbs are identical and each has a resistance of 6 Ω.



Which of the following statements best describes what happens when the filament in one light bulb breaks?

(A) The power drawn by the circuit remains the same.

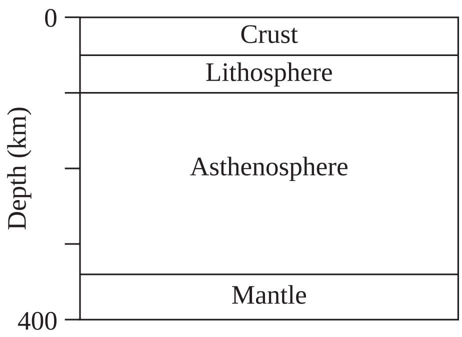
(B) The power drawn by the circuit decreases.

(C) The power drawn by the circuit increases.

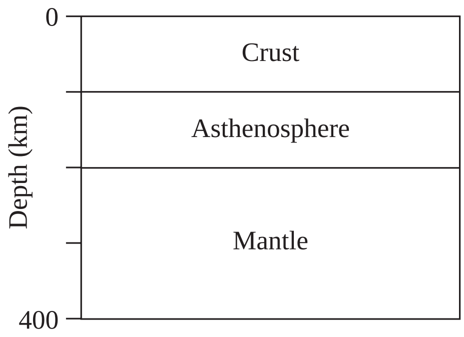
(D) No power is drawn by the circuit.

9. With regard to currently accepted models of the internal structure of the Earth, which of the following diagrams shows the asthenosphere in its correct relationship with other layers of the Earth?

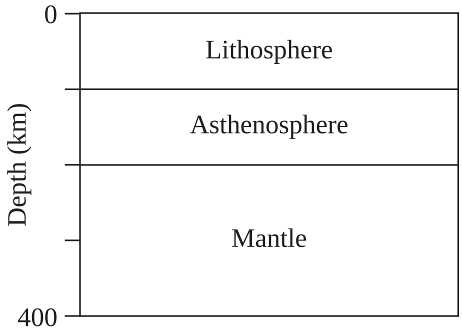
(A)



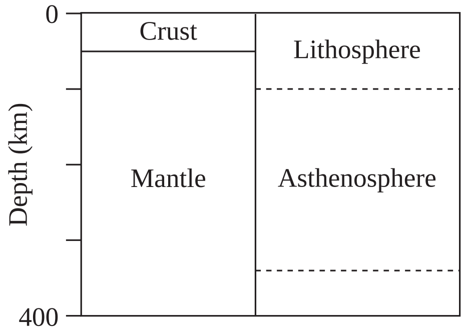
(B)



(C)



(D)



10. Which of these represents a correct sequence of events in the growth of a multicellular organism?

(A) Meiosis, cell differentiation, and cell enlargement.

(B) Meiosis, mitosis, fertilisation, and cell enlargement.

(C) Mitosis, fertilisation, cell differentiation, and cell enlargement.

(D) Mitosis, cell differentiation, and cell enlargement.

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. The koala can survive on a diet of eucalyptus leaves. Eucalyptol is the chief constituent of eucalyptus oil and contains 77·9% C, 10·4% O and the remainder H.

(a) Determine the empirical formula for eucalyptol.

(b) What is the molecular formula of eucalyptol if its relative molecular mass was determined experimentally as 155?

(c) Calculate the mass of carbon dioxide produced through the complete combustion of 10·0 g of eucalyptol.

12. A 1·25 g sample of a monoprotic acid (HZ) was dissolved in 50·0 mL of water. The volume of 0·0900 mol L^{-1} sodium hydroxide solution required to reach the equivalence point was 41·2 mL.

(a) Write a chemical equation for the reaction between HZ and sodium hydroxide solution.

(b) Calculate the moles of sodium hydroxide used to reach the equivalence point.

(c) Calculate the molecular mass of HZ.

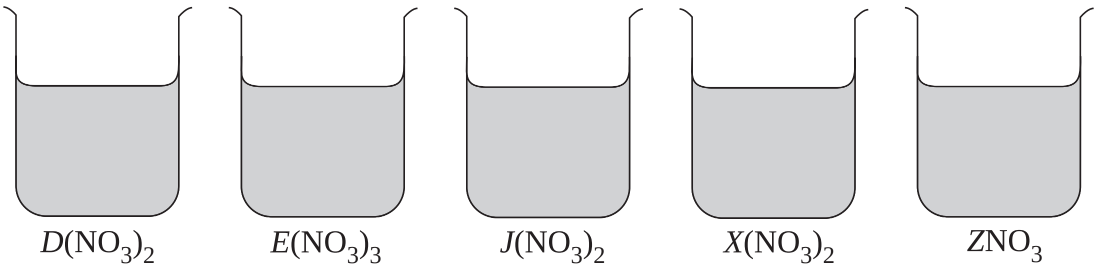
13. Solid lead(II) sulfide occurs in nature as the mineral galena. A sample is 92·3% pure. When galena is heated at high temperature with excess oxygen, lead(II) oxide and sulfur dioxide are produced. The sulfur dioxide reacts with water and acts as an environmental pollutant.

(a) Write a chemical equation for the reaction between lead(II) sulfide and oxygen.

(b) Calculate the volume of gas that would be collected at 298 K and 101·3 kPa, when one tonne of this sample of galena is heated at high temperature with excess oxygen.

(c) Write a chemical equation for sulfur dioxide reacting with water.

14. This question relates to the information given in the diagram below. Each beaker contains a solution of a specific metal ion, as represented below.



A strip of metal, *X*, is placed into each solution. Reactions are observed in $J(NO_3)_2$ and $D(NO_3)_2$ only.

A strip of metal, *E*, reacted with $X(NO_3)_2$ and ZNO_3. It was not tested in the other three solutions.

A strip of metal, *J*, does not react appreciably with any of the five solutions.

(a) Complete the table in the Section II Answer Book.

(i) State the species that is the:

- strongest reductant;
- weakest reductant.

(ii) Give a reason(s) for each species you chose.

(b) Write an ionic equation to describe the reaction that would exhibit the highest electrical potential from the information given above.

15. A pile driver has a hammer head of mass 185 kg. The hammer head is lifted to a height of 5·00 m above a pole. When dropped, the hammer head drives the pole 13·0 cm into the ground.

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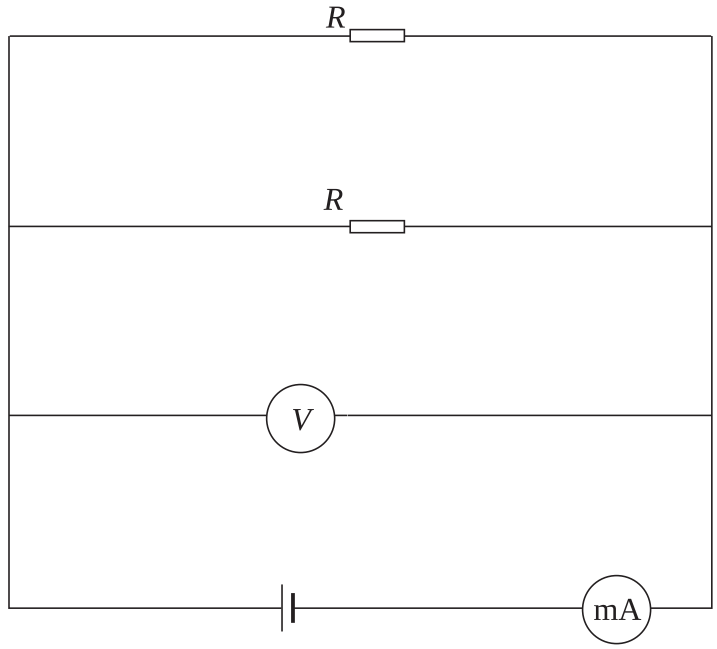
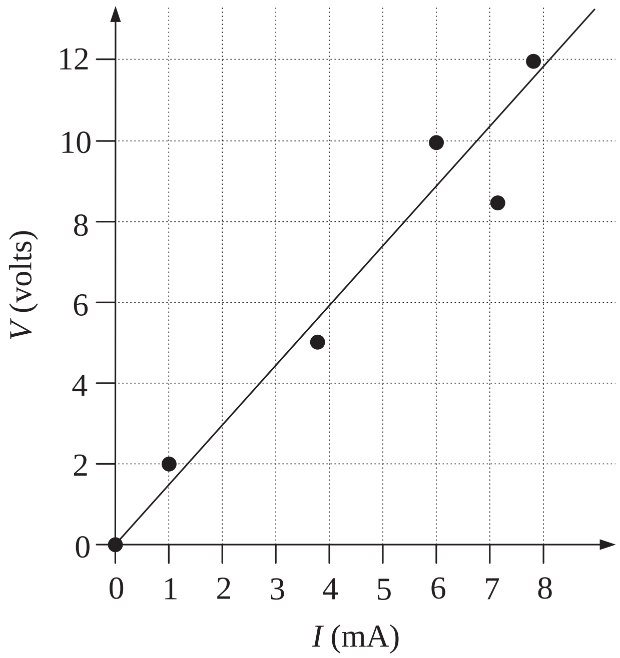
(a) What is the kinetic energy of the hammer head just before it strikes the pole?

(b) What is the average force of the pole on the hammer head while the pole is moving?

16. A circuit consisting of a power supply, a voltmeter, a milliammeter, and two identical but unknown resistors, is constructed as shown below.



A student conducted an experiment with this circuit to verify Ohm's law. She recorded readings on the meters and graphed her results as shown.



(a) Determine the value of *R*.

(b) When the power supply is 9 V, what is the current drawn by the circuit?

17. A 2 kW heater, a 600 W microwave oven and a 100 W lamp are connected in parallel to a 240 V power supply.

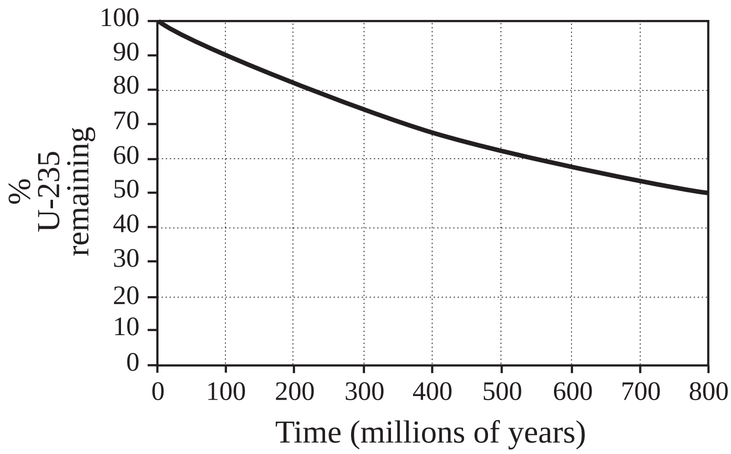
(a) What is the current drawn by each appliance?

(b) This circuit is protected by a circuit breaker that will trip when the current in the circuit is greater than 10 A. Which of the devices could be used in the circuit at the same time? Show working to support your answer.

18. The discovery of a 115 million-year-old placental mammal fossil, *Ausktribosphenos nyktos*, in Victoria in 1997 caused much scientific interest, and challenged the current understanding of early mammalian evolution and distribution.

(a) Explain a difficulty facing palaeontologists trying to develop an evolutionary history.

(b) Assume that a layer of igneous rock occurs in association with the layer in which this fossil was found. The igneous rock is radiometrically dated using U-235/Pb-207. Part of the decay curve is shown below.



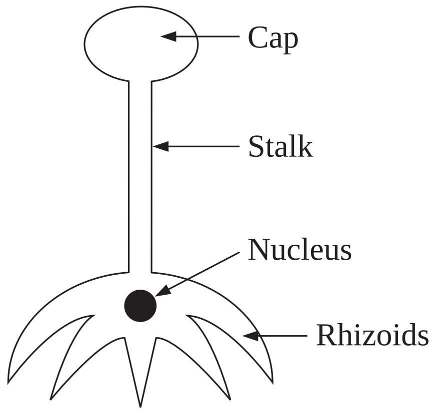
What percentage of the original U-235 atoms would be present in the rock?

(c) Explain why the C-14 method is unsuitable for radiometric dating of this fossil.

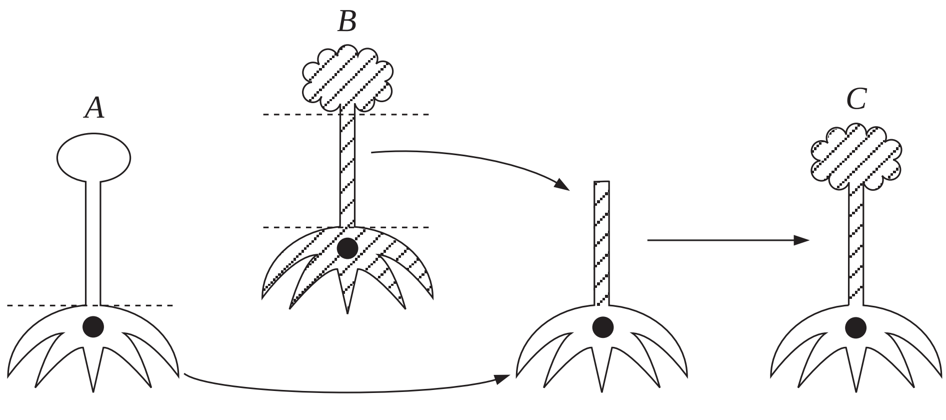
19. In 1961 Max Kleiber, a German physiologist, published a classic text on animal metabolism called *The Fire of Life*. Kleiber viewed cellular respiration and combustion (burning) as similar processes.

List THREE differences between cellular respiration and combustion (burning). Explain the significance of these differences.

20. Differentiation of cells in multicellular organisms is similar and often best studied in single-celled organisms. The diagram shows a species of giant single-celled algae.



Different species of these algae can be identified by the shape of their cap. A grafting experiment using species *A* and *B* is shown below.



Using current knowledge of the function of the nucleus:

(a) give an explanation that accounts for the formation of the cap in *C*;

(b) explain the observation that when the cap in *C* is removed, the new cap formed is the same as the cap of species *A*.

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. The melting points of three compounds are given in the table below.

Oxide	*Melting point* (°C)
Na_2O	sublimes at 1275
SiO_2	1610
P_4O_{10}	580

Complete parts (a) to (e) in the table in the Section III Answer Book.

(a) Name the type of bonding within each compound.

(b) Identify the structure of each compound in its solid state.

(c) Describe the electrical conductivity of each compound in its solid state.

(d) Describe the electrical conductivity of the mixture produced when 1 g of each compound is shaken with 10 mL of water.

(e) Describe the acid–base properties determined if the pH of each mixture produced in part (d) is measured.

22. The table below gives the formula and melting point for the hydrides of some group VI elements.

Formula	*Melting point* (°C)
H_2S	–86°C
H_2Se	–64°C
H_2Te	–49°C

(a) Describe the general trend in melting points for these hydrides.

(b) Explain the above trend.

(c) The melting point of water, another hydride of a group VI element, is an exception to this trend.

(i) Name the intermolecular force exhibited by water that causes this exception to the general trend.

(ii) Draw a diagram that clearly illustrates this intermolecular force between water molecules.

(iii) Name another chemical that exhibits the same intermolecular force.

Please turn over

23. The following steps are involved in the extraction of iron from its ores.

Step 1	$C(s)$	+	$\frac{1}{2}O_2(g)$	$\rightarrow$	$CO(g)$		
Step 2	$3Fe_2O_3(l)$	+	$CO(g)$	$\rightarrow$	$2Fe_3O_4(l)$	+	$CO_2(g)$
Step 3	$Fe_3O_4(l)$	+	$CO(g)$	$\rightarrow$	$3FeO(l)$	+	$CO_2(g)$
Step 4	$FeO(l)$	+	$CO(g)$	$\rightarrow$	$Fe(l)$	+	$CO_2(g)$

(a) For Step 1 described above, write the half-equation for:

(i) oxidation;

(ii) reduction.

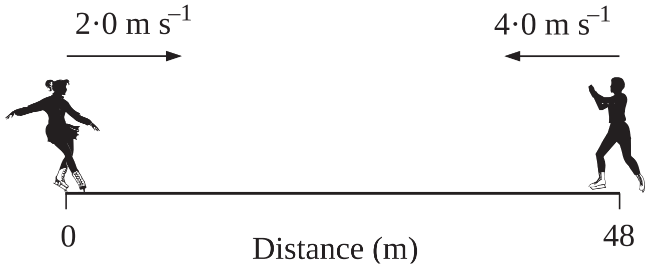
(b) For Step 2:

(i) name the species that is acting as the reductant;

(ii) how many electrons are transferred during the reaction described by the equation as written?

(c) Calculate the mass of carbon required to produce 10 tonnes of pure iron from Fe_2O_3.

24.



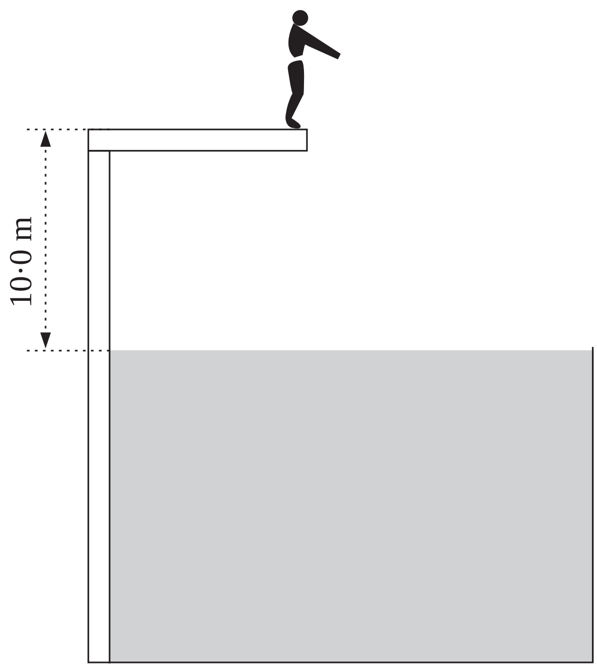
Two ice dancers approach each other from opposite ends of a 48 m frictionless ice-skating rink as shown in the diagram. The female ice dancer has a mass of 53 kg and a constant speed of 2·0 m s^{-1}. The male ice dancer has a mass of 72 kg and a constant speed of 4·0 m s^{-1}. The dancers meet, link arms and move together.

(a) Complete the table in the Section III Answer Book that shows the position of each dancer over time.

(b) Use the table to determine when the dancers meet and their position on the ice.

(c) Calculate their combined velocity immediately after the collision.

25. A 55·0 kg diver drops from a tower 10·0 m above a pool as shown in the diagram, not drawn to scale.

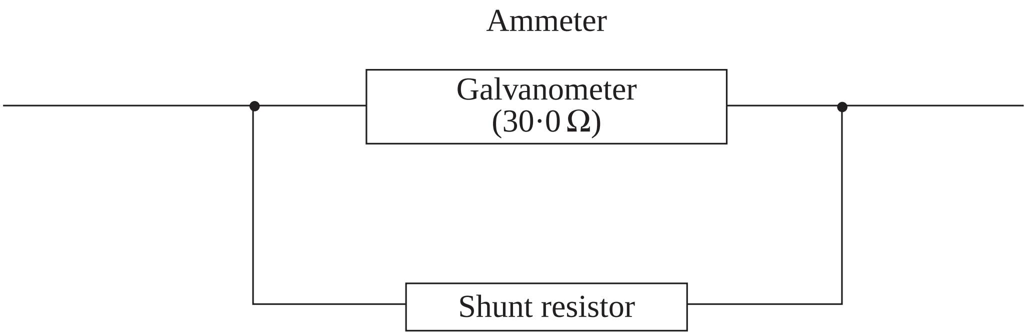


(a) What is the velocity of the diver as she enters the water?

(b) What is the net work done by the water in decelerating the diver to 0 m s^{-1}?

(c) If the average force exerted by the water is 1350 N, what is the distance below the water surface where the diver comes to rest?

26. The ammeter shown below consists of a shunt resistor in parallel with a galvanometer. The galvanometer measures small currents up to 105 μA and has a resistance of 30·0 Ω. The ammeter measures up to 12·0 mA.



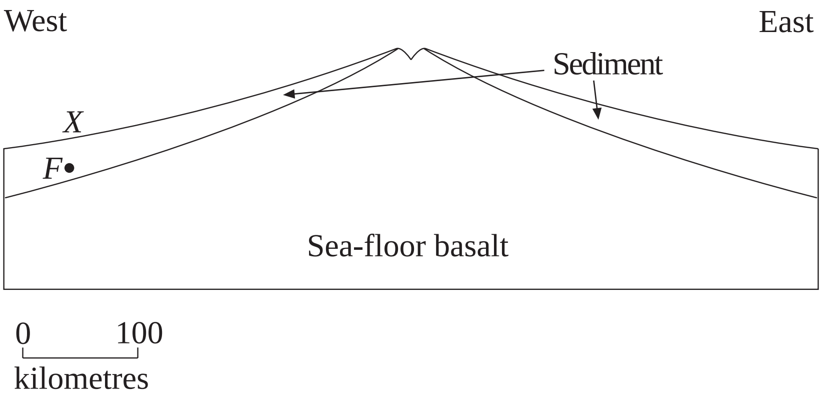
(a) Determine the resistance of the shunt resistor.

(b) A student wants to measure the current drawn by a 4·00 W pilot lamp connected to a 240 V power supply.

Could the student use the ammeter described above? Use calculations to support your answer.

(c) Why would an IDEAL ammeter have zero resistance?

27. The diagram below represents a mid-ocean ridge and the adjacent sea floor with associated sediments.



(a) Explain the absence of sediment cover on the crest of the mid-ocean ridge.

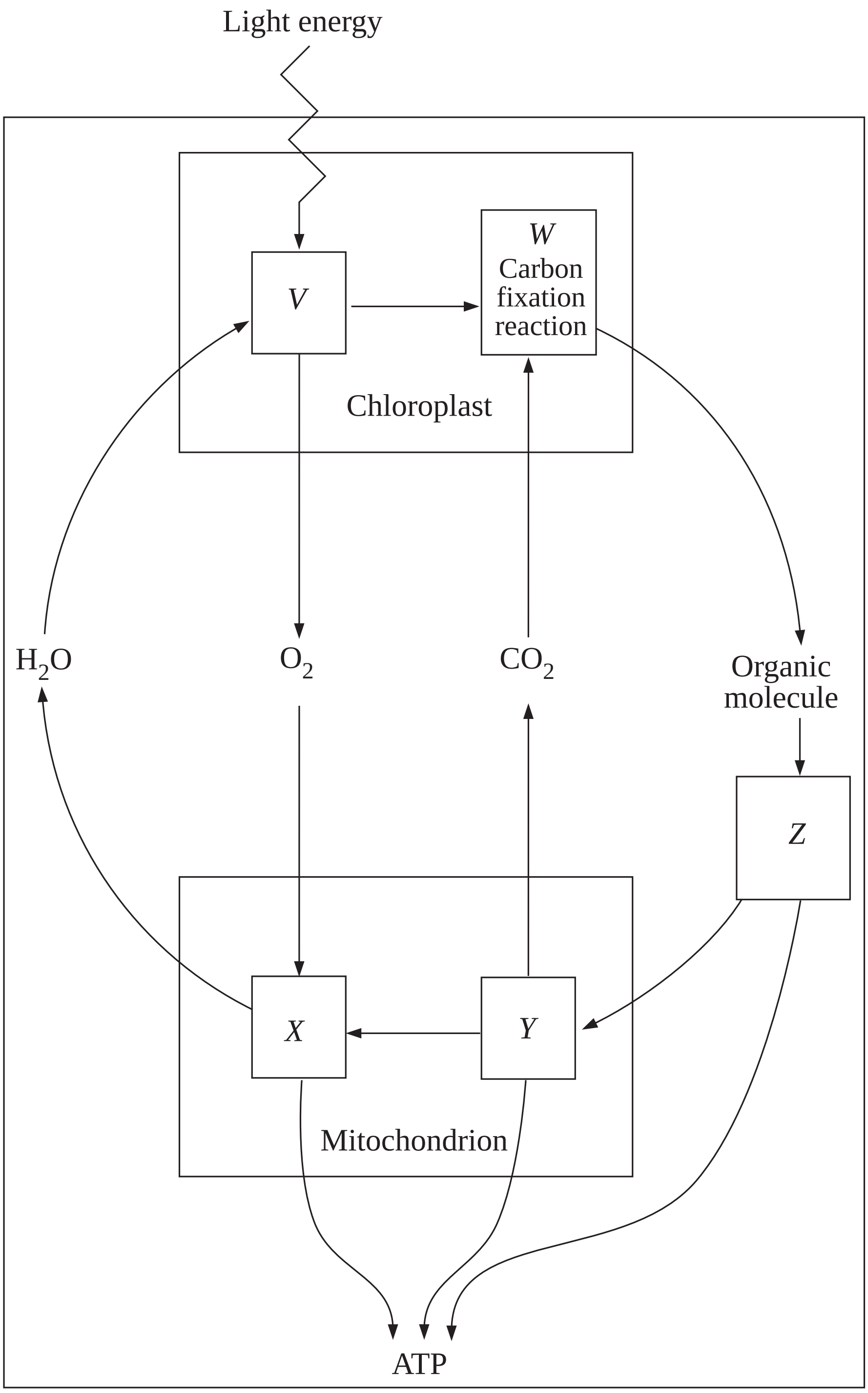
(b) Drilling down through the sediments at location *X* provided cores that contained a particular fossil at point *F* which is two-thirds of the way down to the sea-floor basalt. On the diagram in the Section III Answer Book, mark in ALL places where the sea-floor basalt is the same age as the fossil at *F*.

(c) If the fossil at *F* is 5 million years old, calculate the rate of spreading of the sea floor west of the mid-ocean ridge. Express your answer in cm/year.

(d) Explain the role of the asthenosphere in the lateral movement of lithospheric plates.

28. The diagram shows a series of chemical reactions that can take place within a plant cell.

V, *W*, *X*, *Y* and *Z* represent these reactions.



(a) Name each of the chemical reactions labelled *V*, *X*, *Y* and *Z*.

(b) Which one of the series of chemical reactions *V*, *W*, *X*, *Y* or *Z*, in the absence of oxygen, may lead to the production of CO_2 and ethanol?

(c) Draw the structural formula of ethanol.

SECTION IV

Attempt ALL questions.

Questions 29–30 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. (a) At the start of the Cambrian Period (570 million years BP), fossils suddenly became abundant.

(i) What structural change occurred in organisms at that time which resulted in increased fossilisation?

(ii) What benefit did this structural change provide to these organisms?

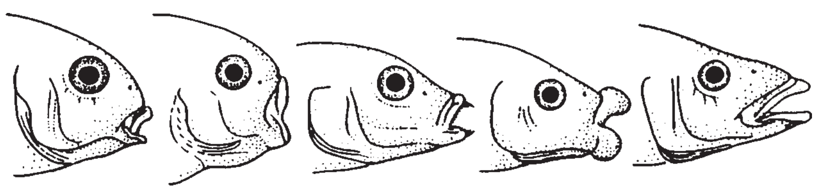
(iii) Fossils within this period include index fossils. Apart from widespread geographic distribution, what is another property that is characteristic of index fossils?

(b) Scientists have used the principle of superposition to support evolutionary theory.

(i) Explain the principle of superposition.

(ii) Describe the relationship between the principle of superposition and evolutionary theory.

(c) The diagram shows a sample of head forms from some of the hundreds of Cichlidae fish species that inhabit the Great African Lakes. These fish species display complex courtship behaviour. Related species often differ in body colour during reproduction.



Pseudotropheus tropheops — *Petrotilapia tridentiger* — *Labidochromis vellicans* — *Haplochromis euchilus* — *Haplochromis polyodon*

Biologists have concluded that these species are the result of natural selection.

(i) Outline a sequence of events that could have resulted in this diversity of species.

(ii) Explain why it is likely that this diversity of species may be maintained.

30. A vanadium redox-flow battery has been developed at the University of New South Wales. The battery consists of several cells connected in series.

(a) The following half-equation describes the reaction occurring at the negative electrode of each cell in the vanadium redox-flow battery.

$$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O \qquad E° = 0{\cdot}361\ \text{V}$$

The concentration of V^{3+} present in one half-cell of the battery could be determined by titration with acidified potassium permanganate solution.

(i) Write the net ionic equation for the titration reaction.

(ii) 38·7 mL of 0·206 mol L^{-1} solution of acidified potassium permanganate is required to completely react with the V^{3+} contained in a 25·0 mL aliquot from the half-cell. Calculate the concentration of V^{3+} in the half-cell.

(iii) Why is acidified potassium permanganate suitable for this titration?

(b) The following half-equation describes the reaction occurring at the positive electrode of each cell in the vanadium redox-flow battery.

$$VO_2^{\ +} + 2H^+ + e^- \rightleftharpoons VO^{2+} + H_2O \qquad E° = -1{\cdot}000\ \text{V}$$

Calculate the standard potential for one cell of the battery.

(c) While the battery is being discharged, the concentration of VO^{2+} in each half-cell decreases from 1·9 mol L^{-1} to 0·20 mol L^{-1}. The volume of solution in each half-cell is 1·8 L.

(i) How many moles of electrons are produced in each cell during the discharge?

(ii) How much charge is carried by the electrons in each cell during the discharge?

(iii) The average current provided by one cell over the time of discharge is 9·5 A. How long does it take to discharge the cell?

(iv) Three of these cells, each of resistance 0·18 Ω, are connected in series to form a battery. Calculate the voltage of this battery.

(v) What is the average power generated by this battery?

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*	9·8 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* (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	79	Symbol of element
	Au	
Atomic Mass	197·0	
	Gold	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.