Unit 1: The Core Principles of Chemistry

Section A

Question Number	Question	
1	Going across a period in the Periodic Table from left to right, the GENERAL trend is that A the bonding in the element itself changes from ionic to covalent B the number of neutrons in the nucleus increases C the first ionisation energy decreases D the metallic character increases	
	Correct Answer	**Mark**
	B	1

Question Number	Question	
2	The electron configurations of argon, iron, chlorine and one other element are given below, but not in order. Which one represents the unnamed element? A $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6\, 3d^6\, 4s^2$ B $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6$ C $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^4$ D $1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^5$	
	Correct Answer	**Mark**
	C	1

Question Number	Question	
3	Buckminsterfullerene is a carbon molecule with formula C_{60} which can trap metal ions in its structure. Which of the following compounds of buckminsterfullerene would give a line of mass/ charge ratio at 837.3 in a mass spectrometer? A Na_4C_{60} B $K_3\, C_{60}$ C $Ca_3\, C_{60}$ D $Ag\, C_{60}$	
	Correct Answer	**Mark**
	B	1

Question Number	Question	
4 (a)	Which equation is NOT balanced?	
	Correct Answer	**Mark**
	A	1

Question Number	Question	
4 (b)	Which equation shows incomplete combustion?	
	Correct Answer	**Mark**
	D	1

Question Number	Question
5	Which of the equations shown below represents the reaction for which ΔH is the standard enthalpy change of formation, $\Delta H_f^{\ominus}{}_{298}$, for ethanol, C_2H_5OH. Ethanol melts at 156 K and boils at 352 K. A $2C(g) + 6H(g) + O(g) \rightarrow C_2H_5OH(g)$ B $2C(s) + 3H_2(g) + O2(g) \rightarrow C2H_5OH(l)$ C $2C(s) + 3H_2(g) + O(g) \rightarrow C_2H_5OH(g)$ D $2C(s) + 3H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_2H_5OH(l)$

	Correct Answer	Mark
	D	1

Question Number	Question
6 (a)	Which fuel, A, B, C or D, produces most energy per gram on complete combustion?

	Correct Answer	Mark
	A	1

Question Number	Question
6 (b)	Scientists give governments advice on technical issues. What information would scientists use when advising governments on the choice of one of these fuels, if the aim was to minimise carbon dioxide production? A mass of carbon per gram of fuel B mass of carbon per kilojoules produced C number of kilojoules produced per gram D number of kilojoules produced per mole

	Correct Answer	Mark
	B	1

Question Number	Question
7	Which of the following equations represents the first ionisation of sulfur? A $S(s) + e^- \rightarrow S^-(g)$ B $S(g) + e^- \rightarrow S^-(g)$ C $S(s) \rightarrow S^+(g) + e^-$ D $S(g) \rightarrow S^+(g) + e^-$

	Correct Answer	Mark
	D	1

Question Number	Question
8	Which element marked on this graph is a halogen?

Correct Answer		Mark
B		1

Question Number	Question
9 (a)	The first ionisation energies of five consecutive members of the same group in the Periodic Table, in order of increasing atomic number.

Correct Answer		Mark
A		1

Question Number	Question
9 (b)	The first five ionisation energies of an s-block element.

Correct Answer		Mark
B		1

Question Number	Question
9 (c)	The first five ionisation energies of a noble gas.

Correct Answer		Mark
D		1

Question Number	Question
10 (a)	Which hydrocarbon has the same empirical formula as its molecular formula?

	Correct Answer	Mark
	C	**1**

Question Number	Question
10 (b)	Which has a molecular ion in the mass spectrum at mass/charge ratio = 58?

	Correct Answer	Mark
	D	**1**
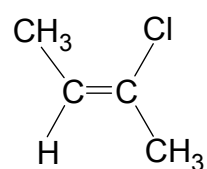
Question Number	Question
10 (c)	Which is neither an alkane nor an alkene?

	Correct Answer	Mark
	A	**1**

Question Number	Question
10 (d)	Which could be 2-methylpropane?

	Correct Answer	Mark
	D	**1**

Question Number	Question
11(a)	Which compound could be made from one of the others in an addition reaction?

	Correct Answer	Mark
	A	**1**

Question Number	Question
11 (b)	Which compound has E-Z isomers?

	Correct Answer	Mark
	C	**1**

Question Number	Question
12	Chemists investigating the mechanism of the reaction of ethene and bromine thought that the first step was the addition of Br^+. To test this, they reacted bromine with ethene in the presence of sodium chloride. If their theory about the first step of the reaction was correct, which product might form as well as 1,2-dibromoethane? A CH_2BrCH_2Na B CH_2BrCH_2Cl C CH_2ClCH_2Cl D CH_2NaCH_2Na

	Correct Answer	Mark
	B	1

Question Number	Question
13	Which of the following is the correct name for the compound below?

A   Z-3-chlorobut-2-ene
B   E-3-chlorobut-2-ene
C   E-2-chlorobut-2-ene
D   Z-2-chlorobut-2-ene

	Correct Answer	Mark
	C	1

Section B

Question Number	Question
14 (a)	Write the equation for the reaction, including state symbols.

	Acceptable Answers	Reject	Mark
	$CuCO_3(s) + H_2SO_4(aq) \rightarrow CO_2(g) + CuSO_4(aq) + H_2O(l)$		**1**

Question Number	Question
14 (b)	The experiment was carried out using 0.025 moles of sulfuric acid of concentration 2.0 mol dm^{-3}. What volume of this sulfuric acid was used? A 5.0 cm^3 B 12.5 cm^3 C 50.0 cm^3 D 125.0 cm^3

	Correct Answer	Mark
	B	**1**

Question Number	Question
14 (c) (i)	It is usual to react the sulfuric acid with a slight excess of copper(II) carbonate. Calculate the mass of copper(II) carbonate needed if a 10% excess is required. [Molar mass of copper(II) carbonate = 123.5 g mol^{-1}]

	Acceptable Answers	Reject	Mark
	(0.025 x 123.5) x 1.1 =(1) 3.396/ 3.40 / 3.4g (g) (1) OR 0.025 mol copper carbonate = 3.087/3.09 (g)(1) 3.087 +10% = 3.396/ 3.40/ 3.4 (g) Full marks for correct answer with no working		**2**

Question Number	Question
14 (c) (ii)	A student doing this experiment chose to use a balance reading to 0.01 g in an attempt to work accurately. Was this choice of balance necessary from the point of view of accuracy? Explain your answer.

	Acceptable Answers	Reject	Mark
	No, as copper carbonate is in excess	No, as molar mass is only to one decimal place	**1**

Question Number	Question		
14 (d)	The sulfuric acid is heated to boiling and the copper(II) carbonate is added in small portions. State the next step needed to prepare pure copper(II) sulfate solution? Justify your answer.		
	Acceptable Answers	Reject	Mark
	Filter to remove excess copper carbonate		1

Question Number	Question	
14 (e) (i)	What is the molar mass of $CuSO_4.5H_2O$?	
	Answer	Mark
	249.6	1

Question Number	Question		
14 (e) (ii)	3.98 g of $CuSO_4.5H_2O$ crystals were obtained in the experiment Calculate the percentage yield in this experiment.		
	Acceptable Answers	Reject	Mark
	Expected yield = 0.025 x 249.6 (1) = 6.24g % yield = (100 x 3.98/6.24)= 63.8/63.78% (1)		2

Question Number	Question		
15 (a) **QWC** **(i) & (iii)**	Describe the bonding in the element magnesium and explain why it is a good conductor of electricity.		
	Acceptable Answers	**Reject**	**Mark**
	(Lattice of) positively charged ions/ ions with 2+charge (1) held together by (electrostatic) attraction to delocalised electrons (1) Delocalised electrons /free electrons/ electrons in sea of electrons are free to move and carry charge / current (1)	Incorrect use of the terms atom or molecule for ion. Incorrect descriptions of delocalised electrons.	3

Question Number	Question		
15 (b) (i)	Draw a diagram (using dots or crosses) for the ions in magnesium fluoride showing ALL the electrons and the ionic charges on: the magnesium ion		
	Acceptable Answers	**Reject**	**Mark**
	Mg^{2+} shown as 2,8 (1)		1

Question Number	Question		
15 (b) (ii)	the fluoride ion		
	Acceptable Answers	**Reject**	**Mark**
	F^- shown as 2,8 (1)		1

Question Number	Question		
15 (c)	Under what conditions does magnesium fluoride conduct electricity? Explain your answer.		
	Acceptable Answers	**Reject**	**Mark**
	When molten/ when dissolved in water so that ions can move/ lattice breaks down (1)	Dissolved in other solvents. Reference to atoms or molecules rather than ions.	1

Question Number	Question		
15 (d) (i)	Use the data above to estimate the percentage isotopic composition of the sample of magnesium. Hence calculate the average atomic mass of this sample of magnesium.		
	Acceptable Answers	**Reject**	**Mark**
	77% ^{24}Mg, 10% ^{25}Mg, 13% ^{26}Mg (1) Average atomic mass $$\frac{((77 \times 24) + (10 \times 25) + (13 \times 26))}{100} = 24.36 = 24.4g \quad (1)$$		2

Question Number	Question		
15 (d) (ii)	Why do the three isotopes have the same chemical properties?		
	Acceptable Answers	Reject	Mark
	Have same electron configuration	Same number of electrons in outer orbit	**1**

Question Number	Question		
15 (e) (i)	Oceanographers studying plankton found that a sample of seawater contained 1.20 nanomol dm^{-3} of chlorophyll, $C_{55}H_{77}MgN_4O_5$. What mass of magnesium would be present in 1.00 cm^3 of this sample of seawater? Give your answer to THREE significant figures.		
	Acceptable Answers	Reject	Mark
	1.20 x 10^{-9} mol of Mg per dm^3 (1) (1.20 x 10^{-9} x 24.3 x 10^{-3}) = 2.92 x 10^{-11} / 29.2 x 10^{-12} (g) (1) max 1 for more/less than 3 significant figures eg 2.916		**2**

Question Number	Question	
15 (e) (ii)	X-ray diffraction can be used to locate atoms or ions in molecules like chlorophyll. X-rays are scattered by the electrons in atoms and ions. In chlorophyll the atoms of one of the elements still cannot be located with certainty by this technique. Suggest which element is most difficult to locate.	
	Correct Answer	Mark
	Hydrogen because it has the least number of electrons per atom	**1**

Question Number	Question
16 (a)	Calculate the number of molecules in 50 dm^3 of nitrogen gas under these conditions.

The Avogadro constant = 6.02×10^{23} mol^{-1}. |

	Acceptable Answers	Reject	Mark
	$(6.02 \times 10^{23} \times \dfrac{50}{24})$=		1
	1.25×10^{24} / 1.254×10^{24} / 1.26×10^{24}		1
	Allow TE from a		

Question Number	Question
16 (b)	Calculate the mass of sodium azide that would produce 50 dm^3 of nitrogen gas.

	Acceptable Answers	Reject	Mark
	M_r = (23 + 42) = 65(1)

Mass = $(2 \times 65 \times \dfrac{50}{72})$ (1)

= 90/ 90.3g (1)   Allow TE from (c) | Wrong unit eg kg | 3 |

Question Number	Question
16 (c)	What will happen to the temperature in the airbag when the reaction occurs?

	Correct Answer	Mark
	decrease	1

Question Number	Question
16 (d)
QWC
(i) & (iii)	The airbag must be strong enough not to burst in an accident. An airbag which has burst in an accident is hazardous if the sodium azide in it has decomposed.
Explain why this is so.

	Acceptable Answers	Reject	Mark
	Sodium is hazardous (1)

May go on fire with water/ produces flammable gas with water/ produces explosive gas with water/ produces strong alkali with water/ reacts with moisture on skin and becomes hot /corrosive (1)

2nd mark depends on reference to sodium | Unspecific comments about sodium being poisonous / toxic / flammable without reference to water. | 2 |

Question Number	Question		
17 (a) (i)	Give the mechanism for REACTION 1.		
	Acceptable Answers	Reject	Mark
		Inaccurate placing of curly arrows	**3**

Question No	Question		
17 (a) (ii)	Explain why compound A and NOT its structural isomer is the major product in REACTION 1.		
	Acceptable Answers	Reject	Mark
	The secondary carbocation/carbonium ion is more stable than the primary (so forms when H^+ adds) OR The secondary carbocation/carbonium ion is stable because the methyl groups are electron donating		**1**

Question Number	Question		
17 (a) (iii)	Name compound A formed in REACTION 1.		
	Acceptable Answers	Reject	Mark
	2-bromopropane		**1**

Question Number	Question		
17 (b)	What is added in reaction 2 to make the product $CH_2(OH)CH(OH)CH_3$?		
	Acceptable Answers	Reject	Mark
	Acidified potassium manganate(VII) / potassium permanganate / $KMnO_4((aq))$		**1**

Question Number	Question		
17 (c)	Complete the balanced equation for the formation of poly(propene) in Reaction 3 USING DISPLAYED FORMULAE .		
	Acceptable Answers	Reject	Mark

balanced and double bond broken (1)
CH_3 on side chain (1) | CH_3 in unbranched chain | 2 |

Question Number	Question		
17 (d)	Poly(propene) fibres can be used to make fleece which is used by several horse racing courses to prevent the ground becoming frozen.
State ONE advantage of using poly(propene) instead of natural fibres of similar cost.		
	Acceptable Answers	Reject	Mark
	Poly(propene) is non-biodegradable / won't break down in wet conditions (1)		1

Question Number	Question	
17 (e) (i)	One stage in the mechanism of REACTION 5 is shown below.

$CH_3CH_2CH_3 + Cl^\bullet \rightarrow CH_3CH_2CH_2{}^\bullet + HCl$

What is this step? | |
| | Correct Answer | Mark |
| | propagation | 1 |

Question Number	Question		
17 (e) (ii)	Give the name OR formula of the trace product present in the final mixture which gives evidence for this mechanism.		
	Acceptable Answers	Reject	Mark
	C_6H_{14} / hexane /
Structural, displayed or skeletal formulae of hexane		1

Question Number	Question	
18 (a) (i)	Calculate the energy change which took place. The specific heat capacity of the solution is 4.20 J $g^{-1}K^{-1}$. Which is the correct value for the energy change in joules?	
	Correct Answer	**Mark**
	4410	**1**

Question Number	Question	
18 (a) (ii)	How many moles of copper(II) nitrate were used in the experiment?	
	Correct Answer	**Mark**
	0.015	**1**

Question Number	Question		
18 (a) (iii)	Calculate the enthalpy change for the reaction. You should include a sign and units in your answer.		
	Acceptable Answers	**Reject**	**Mark**
	$(-4.41/0.015) = -294$ kJ mol^{-1} Value (1) Negative sign and units (1) TE for answer to (i)/ answer to (ii)		**2**

Question Number	Question		
18 (a) (iv) **QWC** **(iii)**	Suggest TWO changes you would make to the EQUIPMENT used in order to improve the accuracy of the result.		
	Acceptable Answers	**Reject**	**Mark**
	Any two of: Use an insulated container/(expanded) polystyrene cup Use a lid Use a thermometer calibrated to at least 0.5 ^{o}C		**2**

Question Number	Question		
18 (b) (i) **QWC** **(i) & (iii)**	the student used 2 g rather than 1 g of magnesium.		
	Acceptable Answers	Reject	Mark
	No effect, as all copper nitrate reacts anyway. (1) Enthalpy change is based on mass of solution heating up / SHC of the metal is very low. (1)		**2**

Question Number	Question	
18 (b) (ii) **QWC** **(i) & (iii)**	The heat losses that occurred from the student's beaker.	
	Correct Answer	Mark
	Yes, temperature rise is smaller than it should be(1) So enthalpy change less negative (1)	2

Question Number	Question		
18 (c)	The temperature in the self-heating can needs to increase by 60 °C to produce a hot drink. Suggest a change you could make to the mixture in the experiment in (a) to produce a greater temperature rise. You are NOT expected to do a calculation.		
	Acceptable Answers	Reject	Mark
	Use more concentrated solution (with correspondingly more magnesium).		**1**

Question Number	Question
19 (a)	On the following outline of a Born-Haber cycle complete the boxes A, B, and C by putting in the formula and state symbol for the appropriate species and writing the name of the enthalpy change at D.

$Cu^{2+}(g)$ + $2Br^-(g)$ $\longrightarrow$ $CuBr_2(s)$

B

A

C

D ....

$Cu(s) + Br_2(l)$

	Acceptable Answers	Reject	Mark
	A $Cu(g)$ B $Cu^+(g)$ C $2Br(g)$ 2 marks for all correct but max 1 if state symbols wrong/ missing 1 mark for 2 correct D $\Delta H_f^{(\ominus)}$ / (standard) enthalpy (change) of formation (of $CuBr_2$) (1)		**3**

Question Number	Question
19 (b)	Use the data to calculate a value for the lattice energy of copper(II) bromide. Give a sign and units in your answer.

	Acceptable Answers	Reject	Mark
	$\Delta H_f = \Delta H_{a(Cu)} + E_{m1(Cu)} + E_{m2(Cu)} + 2 \times \Delta H_{a(1/2\ Br2)} + 2 \times E_{aff(Br)} + \Delta H_{latt}$ OR Lattice energy = D-(other enthalpy changes) (1) Can be shown using the numbers = -141.8 - (338.3 + 746 + 1958 + 2x111.9 + 2x-342.6) = -141.8 - 2580.9 =-2722.7 =-2723 (kJ mol^{-1}) (2) max 1 if no multiples of 2 for Br max 2 (out of 3) if positive sign		**3**

Question Number	Question		
19 (c) (i)	What does this suggest about the nature of the bonding in copper(II) bromide?		
	Acceptable Answers	Reject	Mark
QWC	Not 100 % ionic/ has some covalent character	Answers where it is not clear that bonding has some intermediate character, but not entirely ionic or covalent	**1**

Question Number	Question		
19 (c) (ii)	Draw a diagram to show how the smaller copper ion alters the shape of the larger bromide ion.		
	Acceptable Answers	Reject	Mark
	Non-spherical bromide / negative ion with bulge towards copper / positive ion (1)		**1**