Neap:

DTT 2019

Chemistry HSC Year 11

Suggested Solutions and Marking Scheme

Test 1: Module 1 (Properties and Structure of Matter)

- Properties of Matter
- Atomic Structure and Atomic Mass

TOTAL 25 MARKS (45 MINUTES)

PART A

Answer and explanation	Syllabus outcomes and targeted performance bands
Question 1 **A** Compounds with names ending in 'ide' usually contain two elements. This reflects IUPAC nomenclature rules.	CH11–4 Band 2
Question 2 **D** An atom is not a subatomic particle. Protons and neutrons have a mass of approximately 1.0 atomic mass units (amu) and electrons have a mass of approximately 0.0055 amu.	CH11–4 Band 2
Question 3 **C** Metals are found on the left-hand side and centre of the Periodic Table. Non-metals are found on the right. Semi-metals (metalloids) are found along the stepped division between metals and non-metals.	CH11–8 Band 3
Question 4 **C** $\text{R.A.M.} = \frac{(\text{mass of isotope A} \times \%) + (\text{mass of isotope B} \times \%)}{100}$ $= \frac{(35 \times 76) + (37 \times 24)}{100}$ $= 35.5$ amu	CH11–4 Band 4
Question 5 **B** This isotope has an atomic number of 79 and mass number of 197. Hence it has 79 electrons, 79 protons, 118 (197-79) neutrons and 197 nucleons (protons plus neutrons).	CH11–8 Band 3

PART B – 20 MARKS

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 6 **a.** A homogeneous mixture is any mixture that is uniform in composition throughout; the separate components cannot be observed. The mixture is all in the same phase (state). Examples include sea water (salts dissolved evenly throughout the mixture) and the atmosphere (nitrogen, oxygen and other gases mixed evenly). A heterogeneous mixture has a composition that varies from one region to another, with at least two phases that remain separate from each other. If a heterogeneous mixture is studied, the separate components can be seen. Examples include concrete (stones, cement and water) and ice cubes in cola.	CH11–8 Bands 2–3 • Outlines the difference between homogeneous and heterogeneous mixtures. AND • Gives a valid example of both mixtures. 2 • Outlines the difference between homogeneous and heterogeneous mixtures. 1
b. I filter paper II filter funnel III evaporating basin IV filtrate V residue	CH11–2 Bands 3–4 • Identifies all FIVE parts. 2 • Identifies at least TWO parts. 1
Question 7 **a.** calcium fluoride	CH11–2 Band 2 • Correctly identifies compound. 1
b. $\frac{19.3}{68.1} \times 100 = 28.3$	CH11–4 Bands 3–4 • Correctly calculates percentage AND shows working. 1
c. flame test	CH11–3 Band 2 • Correctly identifies test. 1

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PART B – 20 MARKS

ATTEMPT QUESTIONS 6–10

ANSWER THE QUESTIONS IN THE SPACES PROVIDED

Question 6 (4 marks)
The following table contains data on the radii of atoms of Group 1 elements.

Element	Atomic radius ($\times 10^{-12}$ m)
lithium	130
sodium	160
potassium	203
rubidium	216
caesium	235

a. Describe and explain the trend in atomic radii for these elements. 2 marks

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b. Outline the trends of another physical property going down the elements in Group 1 or another named group. 2 marks

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PART B – 20 MARKS

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 6 **a.** The atomic radii increase as we go down the group. This is because extra electron shells/energy levels are being added to hold the 'extra' electrons and this increases the size.	CH11–8 Bands 3–4 • Describes the trend of atomic radii. AND • Explains TWO points. 2 • Describes the trend of atomic radii. AND • Explains ONE point. 1
b. *For example:* Melting point: In Group 1, melting points decrease going down the group.	CH11–8 Bands 3–4 • Names an appropriate trend for a particular group. AND • Correctly describes the trend. 2 • Provides some relevant information. 1
Question 7 The student has confused periods with groups. Allowing for that, some principles have been identified but other points could be made. The answer could include: • The first shell has a maximum of two electrons. • The outer shell has a maximum of eight electrons. • Inner shells can have more than eight electrons. • Transition metals have incomplete inner shells. There is no mention of energy levels.	CH11–8 Bands 4–6 • Gives a clear discussion stating at least THREE relevant points. 3 • Gives a clear discussion stating at least TWO relevant points. 2 • Provides some relevant information. 1

PART B (continued)

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
c. Use the formula: $C_1V_1 = C_2V_2$ $$C_2 = \frac{C_1V_1}{V_2}$$ Where: C_1 = initial concentration → 0.2 mol L^{-1} V_1 = initial volume → $\frac{50}{1000}$ = 0.05 L C_2 = new concentration → unknown V_2 = new volume → $\frac{250}{1000}$ = 0.0250 L $C_2 = \frac{0.2 \times 0.05}{0.25}$ = 0.04 mol L^{-1} *Note: The student could also use the information that the dilution was five-fold.*	CH11–6, 9 Bands 3–4 • Shows appropriate calculations. AND • Provides correct concentration. 1
Question 8 **a.** An excess of silver nitrate was added to ensure that all of the magnesium chloride was reacted.	CH11–9 Bands 2–3 • Gives an appropriate reason. 1
b. The stoichiometry of the reaction shows that two moles of the precipitate (silver chloride) are formed for every one mol of magnesium chloride present, a ratio of 2 : 1. molar mass (*MM*) of silver chlorine = (1 × 107.9) + (1 × 35.45) = 143.4 g number of mol of magnesium chloride = *n* = cV = 0.1 × $\frac{50}{1000}$ = 0.005 number of mol of silver chloride = 0.005 × 2 = 0.010 mass = *m* = *n* × *MM* = 0.010 × 143.4 = 1.43 g *(to three significant figures)*	CH11–9 Bands 4–5 • Uses appropriate equations. AND • Calculates mass accurately. 2 ——— • Uses appropriate equations. 1

PART B (continued)

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 9 **a.** $Cu(s) + 4HNO_3(aq) \rightarrow$ $Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$ Stoichiometry shows two mol of gas are generated for every mol of copper. number of mol of copper, $n = \frac{m}{MM}$ $= \frac{5.63}{63.5}$ $= 0.08866$ volume of gas = n × molar volume = 0.1773 × 24.79 = 4.40 L *(to three significant figures)* *Note: Current NESA data sheet gives 24.79 L as the molar volume under these conditions.*	CH11–9 Bands 5–6 • Uses appropriate formula. AND • Calculates volume accurately. 2 • Uses appropriate formula. 1
b. $PV = nRT$ $V = \frac{nRT}{P}$ $= \frac{0.1773 \times 8.314 \times 293.15}{101.3}$ = 4.27 L *(to three significant figures)*	CH11–9 Bands 2–3 • Uses appropriate equation. AND • Calculates new volume accurately. 1

Question 2

Solid ammonium thiocyanate reacts spontaneously with solid barium hydroxide according to the equation shown below.

$$2NH_4SCN(s) + Ba(OH)_2(s) \rightarrow 2NH_3(aq) + 2H_2O(l) + Ba^{2+}(aq) + 2SCN^-(aq)$$

The mixture becomes much colder as the reaction proceeds.

Which one of the following is accurate when the solution has returned to its initial temperature?

A. The energy stored in the reactants was greater than the energy stored in the products.

B. The energy stored in the products is greater than the energy that was stored in the reactants.

C. There is no difference between the energy stored in the reactants and the products.

D. The total amount of stored energy in the mixture has decreased.

Question 3

A student measures 200 mL of water into a thermally insulated container and records the temperature of the water as 22.0°C. The student adds 0.10 mol $NH_4NO_3(s)$ to the water and stirs the solution until the solid has dissolved. This process is represented by the equation shown below.

$$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq) \qquad \Delta H = +25.4\,\text{kJ mol}^{-1}$$

Given the above information, how will the temperature change?

A. The temperature will rise by 3.04°C.

B. The temperature will fall until the water turns to ice.

C. The temperature will rise to 52.0°C.

D. The temperature will fall to a minimum of 19.0°C.

Question 4

Consider the chemical reaction shown below.

$$H_2(g) + Br_2(g) \rightarrow 2HBr(l) \qquad \text{Heat given out} = 107.4\text{ kJ}$$

Given the above information, which one of the following conclusions is correct?

A. The enthalpy of formation (ΔH^0_f) for HBr(l) is 107.4 kJ mol^{-1}.

B. The enthalpy of formation of HBr(g) would be greater than 107.4 kJ mol^{-1}.

C. The enthalpy of formation (ΔH^0_f) for HBr(l) is –53.7 kJ mol^{-1}.

D. H–H bonds and Br–Br bonds are both stronger than H–Br bonds.

Question 5

Solid vanadium pentoxide (V_2O_5) is employed industrially in the oxidation of sulfur dioxide to sulfur trioxide at 440°C according to the equation shown below.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g) \qquad \Delta H = -99\,\text{kJ mol}^{-1}$$

Without the use of a catalyst, how would the reaction differ?

A. The number of molecules with sufficient energy to react would decrease.

B. ΔH for the reaction would become positive.

C. ΔH for the reaction would be much less.

D. The reactants would form different products.

d. Explain the difference between these values in terms of bonding and thermodynamic quantities. 2 marks

Question 9 (4 marks)

A research scientist has proposed an environmentally safe method of storing solar energy for consumption at night. Electrical current from solar panels is used to convert liquid water at 25.0°C to hydrogen gas and oxygen gas. The oxygen gas is released into the atmosphere and the hydrogen gas is stored under pressure. At night, the hydrogen gas is burned with atmospheric oxygen to produce steam. The steam is used to turn electrical generators.

a. Calculate the amount of electrical energy required to convert 10.0 kg of liquid water to its gaseous elements using standard enthalpies of formation. 1 mark

b. Evaluate the scientist's proposal in terms of your understanding of thermodynamics. 3 marks

PART B (continued)

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 8 **a.** $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$	CH11/12–6, 7 Band 2 • Provides the correct equation, including all states. 1
b. The bonds broken are: 1 mol C–C = 1 × 346 = 346 kJ 5 mol C–H = 5 × 414 = 2070 kJ 1 mol C–O = 1 × 352 = 352 kJ 1 mol O–H = 1 × 465 = 465 kJ 3 mol O=O = 3 × 498 = 1494 kJ Total energy required = 4727 kJ The bonds formed are: 4 moles C=O = 4 × 804 = 3216 kJ 6 moles O–H = 6 × 465 = 2790 kJ Total energy given out = 6006 kJ The energy given out by new bonds forming is greater than the energy required to break the existing bonds, so the overall process is exothermic and ΔH is negative. $\Delta H = -(6006 - 4727) = -1279 \text{ kJ mol}^{-1}$	CH11/12–6, 7 Band 4 • Correctly calculates the total bond breaking energy required. AND • Correctly calculates the total bong forming energy given out. AND • Derives the value of ΔH_c with the correct sign. 2 ——— • Derives the value of ΔH_c with the incorrect sign. 1
c. $\Delta H = \Sigma\Delta H^0_f\text{(products)} - \Sigma\Delta H^0_f\text{(reactants)}$ $\Delta H = (2 \times -393.5 + 3 \times -241.8) - (-277.7)$ $= -1235 \text{ kJ mol}^{-1}$	CH11/12–6, 7 Band 3 • Provides the correct calculation. 1

PART B (continued)

	Sample answer	Syllabus outcomes, targeted performance bands and marking guide
d.	The bond enthalpy calculation takes no consideration of the intermolecular bonds that must be broken in order to convert liquid ethanol to gaseous ethanol. These would be primarily hydrogen bonds with a small contribution of Van de Waals intermolecular bonding. The difference is due to the enthalpy of vaporisation of ethanol. *Note: The bond enthalpy calculation is for the process given below.* $CH_3CH_2OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H = -1235\ kJ\ mol^{-1}$ The second calculation involving enthalpies of formation is for the combustion of liquid ethanol. Using Hess's law, we can write the whole process as the sum of two, as shown below. $CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H = -1235\ \text{kJ mol}^{-1}$ $2CO_2(g) + 3H_2O(g) \rightarrow CH_3CH_2OH(g) + 3O_2(g)$ $\Delta H = +1279\ \text{kJ mol}^{-1}$ (By changing the direction of the equation, we change the sign of ΔH.) Adding these equations together, we obtain: $CH_3CH_2OH(l) \rightarrow CH_3CH_2OH(g)$ $\Delta H = 44\ \text{kJ mol}^{-1}$ *Note: Students are not required to calculate the value of ΔH_{vap}. The actual value is +42.3 kJ mol^{-1}. This discrepancy can be explained by the fact that the bond enthalpies used are always average bond enthalpies.*	CH11/12–6, 7 Band 6 • Identifies the difference as ΔH_{vap} ethanol. AND • Gives ONE reason. 2 --- • Any ONE of the above points. 1

Question 8 (3 marks)

There is a use for the equilibrium constant in exploring the dissociation of acids and bases. It is frequently called the acid-dissociation equilibrium constant and given the symbol K_a. The table below shows some details of ethanoic acid and nitric acid.

Name	**Formula**	$K_{eq}(K_a)$
ethanoic acid	CH_3COOH	1.8×10^{-5}
nitric acid	HNO_3	40

a. Write an expression for the equilibrium constant for hydrochloric acid, showing the species present. 1 mark

b. What does the size of the equilibrium constants tell us about the relative number of hydrogen ions that would be present in equimolar solutions of the two acids? 2 marks

Question 9 (3 marks)

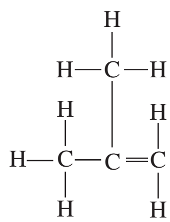
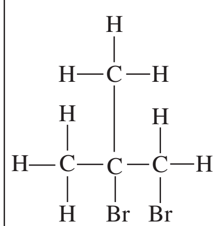
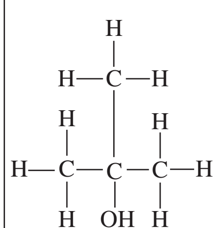
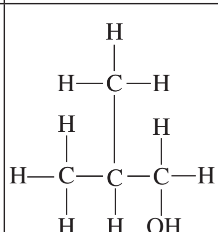
A group of students was investigating the solubility of silver chloride (AgCl) in water at 25°C. Their results indicated that it was 1.51×10^{-5} mol L^{-1}.

a. Calculate the solubility product (K_{sp}) for silver chloride using this data. 2 marks

b. Compare this figure with the accepted value. 1 mark

PART B (continued)

Sample answer	Syllabus outcomes, targeted performance bands and marking guide
Question 8	CH12–6, 14 Bands 3–6

Compound	Structural formula	Justification
compound A C_4H_8		Compound A produces 2-methylpropane when undergoing an addition reaction with hydrogen. This identifies compound A as 2-methylpropene.
compound B $C_4H_8Br_2$		Compound B must be 1,2-dibromo-2-methylpropane formed from the addition of bromine to 2-methylpropene.
compound C C_4H_9OH	 2-methylpropan-2-ol	Compound C is 2-methylpropan-2-ol (or 2-methyl-2-propanol), a tertiary alcohol formed when water is added to 2-methylpropene.
compound D C_4H_9OH	 2-methylpropan-1-ol	Compound D is 2-methylpropan-1-ol (or 2-methyl-1-propanol), a primary alcohol formed when water is added to 2-methylpropene.

Marking guide

- Draws structural formula for each compound.

AND

- Provides justification for each compound. 5

- Correctly draws, with relevant justification, some structural formula. 3–4

- Correctly identifies some chemical characteristics of some compounds. 2

- Provides some relevant information. 1