Y12 Chemistry Mid-Term 1 Exam

Name: …….. Class:……. Date:……..

Q1. Consider the reaction

$$H_2(g) + I_2(g) \rightarrow 2HI\ (g) \qquad \Delta H = -9.0\ kJ\ mol^{-1}$$

The bond energy of H—H = 436 kJ mol^{-1}

The bond energy of H—I = 298 kJ mol^{-1}

It can be deduced that the bond energy of I—I, in kJ mol^{-1}, is **(1)**

☒ **A** 75.5

☒ **B** 84.5

☒ **C** 151

☒ **D** 169

Q2. An experiment was carried out to measure the enthalpy change of the following reaction.

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

50cm^3 of hydrochloric acid was mixed with 50 cm^3 of sodium hydroxide solution. Each solution contained 0.10 mol solute. The temperature rise was 12°C.

Energy transferred (J) = mass of solution × 4.2 × change in temperature

Assume the density of all solutions is 1.0 g cm^{-3}.

What is the enthalpy change of the reaction in kJ mol^{-1}? **(1)**

☒ **A** $-\frac{50 \times 4.2 \times 12}{0.1 \times 1000}$

☒ **B** $-\frac{50 \times 4.2 \times 12}{0.2 \times 1000}$

☒ **C** $-\frac{100 \times 4.2 \times 12}{0.1 \times 1000}$

☒ **D** $-\frac{100 \times 4.2 \times 12}{0.05 \times 1000}$

Q3. Which of the following series shows the elements in order of increasing melting temperature? **(1)**

☒ **A** Li, Na, K

☒ **B** Al, Si, P

☒ **C** Na, Mg, Al

☒ **D** S, Cl, Ar

Q4. When 10 cm^3 of a nitric acid solution reacts with 20 cm^3 of a sodium hydroxide solution, the temperature rise is ΔT.

Repeating the reaction with 15 cm^3 of the same nitric acid solution and 30 cm^3 of the same sodium hydroxide solution would give a temperature rise of **(1)**

- ☒ **A** 0.5 ΔT
- ☒ **B** 0.67 ΔT
- ☒ **C** ΔT
- ☒ **D** 1.5 ΔT

Q5. Which of the following enthalpy changes cannot be measured **directly** by experiment? **(1)**

The enthalpy change of

- ☒ **A** formation of methane.
- ☒ **B** combustion of hydrogen.
- ☒ **C** formation of carbon dioxide.
- ☒ **D** combustion of carbon monoxide.

Q6. Ionization energies provide evidence for the arrangement of electrons in atoms.

(a) (i) Write an equation, including state symbols, to show the **second** ionization energy of magnesium.

..... **(2)**

(ii) Give **two** reasons why the second ionization energy of magnesium is greater than the first ionization energy of magnesium. **(2)**

1 .....

.....

.....

2 .....

.....

.....

(iii) Complete the table by suggesting a value for the **third** ionization energy of magnesium. **(1)**

Ionization number	First	Second	Third	Fourth	Fifth
Ionization energy / kJ mol^{-1}	738	1450		10 500	13 600

(b) (i) Give the electronic configurations of phosphorus and of sulfur in s, p and d notation.

(2)

Phosphorus (atomic number 15)

.....

Sulfur (atomic number 16)

.....

(ii) By reference to your answer in (b)(i), explain why the first ionization energy of sulfur is lower than that of phosphorus.

(2)

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.....

(Total for question = 9 marks)

Q7. Sodium hydrogencarbonate decomposes on heating to form sodium carbonate, carbon dioxide and water.

Reaction 1 $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$

(a) Suggest why it is difficult to measure the enthalpy change of this reaction directly. **(1)**

.....

.....

.....

(b) The enthalpy change can be measured indirectly using the enthalpy changes for the following two reactions and applying Hess's Law.

Reaction 2 $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

Reaction 3 $Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$.

An experiment was carried out to measure the enthalpy change of **Reaction 2**.

100 cm^3 of 1.25 mol dm^{-3} hydrochloric acid was placed in a polystyrene beaker with capacity 200 cm^3.

The initial temperature of the acid was 21.5°C.

8.00 g of solid sodium hydrogencarbonate was added, a lid was placed on the beaker and the mixture was stirred. The lowest temperature of the mixture was 14.2°C.

(i) Explain why the beaker used in this experiment is large. **(1)**

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(ii) Show by calculation that the hydrochloric acid is present in excess.

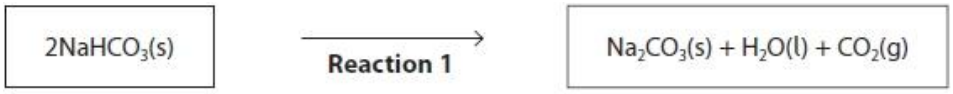
(2)

(iii) Calculate the energy transferred and hence the enthalpy change of the reaction in kJ mol^{-1}.
Include a sign and units in your answer.
Use the equation: Energy transferred (J) = 100 × 4.18 × temperature change.

(3)

(iv) The enthalpy change for **Reaction 3** was found to be –36.3 kJ mol^{-1}.
Complete the Hess cycle by adding the appropriate arrows and formulae to the outline.
Use your completed cycle to calculate the enthalpy change for **Reaction 1**.

(4)



Δ*H* for **Reaction 1** = ... kJ mol^{-1}

(Total for question = 11 marks)

Mark Scheme

Q1.

Question Number	Correct Answer	Mark
	The only correct answer is C ***A*** *is not correct because it has used a wrong sign in the calculation and then divided the answer by 2* ***B*** *is not correct because it has used a wrong sign in the calculation* ***D*** *is not correct because the wrong sign for enthalpy change has been used*	**(1)**

Q2.

Question Number	Correct Answer	Reject	Mark
	C		**(1)**

Q3.

Question Number	Correct Answer	Mark
	The only correct answer is C ***A*** *is not correct because melting temperatures decrease down Group 1* ***B*** *is not correct because the melting temperature of P is less than Si* ***D*** *is not correct because the melting temperature of Ar is less than the others*	**(1)**

Q4.

Question Number	Correct Answer	Mark
	C is the correct answer Because the same proportions of solutions of the same concentration are used	1

Q5.

Question Number	Correct Answer	Mark
	A	**1**

Q6.

Question Number	Acceptable Answers	Reject	Mark
(a)(i)	$Mg^{+}(g) \rightarrow Mg^{2+}(g) + e^{(-)}$ OR $Mg^{+}(g) - e^{(-)} \rightarrow Mg^{2+}(g)$ OR $Mg^{+}(g) + e^{(-)} \rightarrow Mg^{2+}(g) + 2e^{(-)}$ **1st mark** Correct species for reactants **and** products **(1)** **2nd mark** Correct state symbols **This mark can only be awarded if first mark has already been awarded.** **(1)** **NOTE** Award state symbols mark if '$X^{+}(g)$' OR 'MG' used instead of 'Mg' $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{(-)}$ **scores (0)**	"MG" for first mark	**2**

Question Number	Acceptable Answers	Reject	Mark
(a)*(ii)	Any **TWO** from: Electron (in Mg^+) is being removed from a positive ion **(1)** Electron being removed is closer to the nucleus (in Mg^+) / Mg^+ is smaller (than Mg) **(1)** Proton: electron ratio greater (in Mg^+) / remaining e^- more tightly held (in Mg^+) **(1)** Greater (force of) attraction between nucleus and (outermost) electron (in Mg^+) **(1)** Electron repulsion is less in Mg^+ (than Mg) **(1)** **IGNORE** References to "effective nuclear charge (ENC)" / high charge-density in Mg^+ / references to shielding	"Mg^+ has more protons than Mg" scores **(0)** overall Electron is being removed from a new shell/different shell / 2nd shell scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
(a)(iii)	Any value in range 5000 to 9000 (kJ mol^{-1}) **NOTE** Actual value is 7730 (kJ mol^{-1})		**1**

Question Number	Acceptable Answers	Reject	Mark
(b)(i)	(Phosphorus) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ ALLOW p_x, p_y, p_z notation / upper case **(1)** (Sulfur) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ ALLOW p_x, p_y, p_z notation / upper case **(1)** ALLOW Noble gas core: [Ne] for $1s^2\ 2s^2\ 2p^6$		**2**

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	**1st mark – idea of paired e^- in S** In sulfur, spin-pairing has occurred / two electrons in the same orbital / paired e^- Note: **Just** $3p^4$ stated for S does not gain this mark. **ALLOW** an 'electrons-in-box' diagram, showing two electrons in the same orbital **(1)** **2nd mark – idea of repulsion** (resultant increase in) **repulsion** **(1)** **ALLOW** **Just** phosphorus has a half-filled sub-shell which is more stable (max **(1)**)		**2**

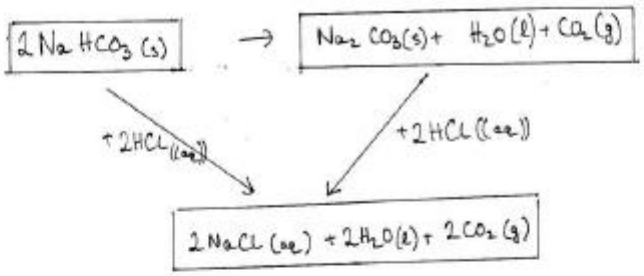
Q7.

Question Number	Acceptable Answers	Reject	Mark
(a)	Difficult to measure energy supplied/ take measurements while heating (the sample)/ to decide when reaction is complete ALLOW Difficult to measure the temperature of a solid Difficult to measure heat supplied/ heat absorbed	Just "because requires heating" Because of heat losses	**(1)**

Question Number	Acceptable Answers	Reject	Mark
b(i)	To protect from or prevent (the acid/ reaction mixture) spraying/ spitting/ splashing out/ bubbling over/ spilling with reason eg due to excessive frothing / stirring IGNORE Reaction is vigorous	Just "spilling"	**(1)**

Question Number	Acceptable Answers	Reject	Mark
b(ii)	Mol HCl = (100 x 1.25 / 1000) $=1.25 \times 10^{-1}$ / **0.125** **(1)** Mol $NaHCO_3$ = (8.0/84) = 0.095238/ **0.0952** Ignore SF except 1 SF **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
b(iii)	Energy transferred = (100 x 4.18 x 7.3) = **3051.4 (J) / 3.0514 kJ** Ignore sign Ignore SF except 1 or 2 SF **(1)** ΔH = + 3051.4 ÷ 0.095238 Allow TE from incorrect $NaHCO_3$ from (b) (ii) **(1)** = **+ 32040** J mol^{-1} / **+32.040/ +32.0** kJ mol^{-1} ALLOW answers using rounded values of 0.095238 e.g. **+32.120** kJ mol^{-1} if based on 0.095 **(1)** IGNORE SF Use of 0.125 mol does NOT score MP2, but will score MP3 for +24.41 kJ mol^{-1}		**(3)**

Question Number	Acceptable Answers	Reject	Mark
b(iv)	 $2NaCl + 2H_2O + 2CO_2$ in bottom box IGNORE State symbols **(1)** Two arrows pointing downwards each with 2HCl OR Two arrows pointing downwards with 2HCl on each side of the equation in both top boxes **(1)** ALLOW Right hand arrow pointing upwards and 2HCl if (2x) (b)(iii) + 36.3 used correctly in calculation ΔH for Reaction 1 = **2**x answer to (b)(iii) –(-36.3) **(1)** = (+)100.3 (kJ mol^{-1}) **(1)** If factor of 2 missing in MP3 allow TE in MP4 = (+)68.3 (kJ mol^{-1}) TE on incorrect answer to (b)(iii) Answer of +3.05 in (b)(iii) gives (2x 3.05 +36.3) = (+)42.4 (kJ mol^{-1}) Answer of +24.41 in (b)(iii) gives (2x 24.41 +36.3) = (+)85.12 (kJ mol^{-1})	Cycles using ΔH_f	**(4)**