07 Chemical Energetics I

Set A Foundations

Name | Time **1 hour** | Total **41 marks** | Score ____ / 41

A Data Booklet may be used. Specific heat capacity of water = 4.18 J g^{-1} K^{-1} unless stated otherwise.

A From the lesson

13 MARKS

1 $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ $\Delta H = -92$ kJ mol^{-1}. Find ΔH for $NH_3(g) \rightarrow \frac{1}{2}N_2(g) + 1\frac{1}{2}H_2(g)$.

[1]

/1

Source: Learners' Alley, Chemical Energetics I slides

2 COMMON Write the equation, with state symbols, for each standard enthalpy change.

(a) ΔH_f of methanol, $CH_3OH(l)$

[1]

(b) ΔH_c of ethane

[1]

(c) lattice energy of MgO

[1]

(d) ΔH_{at} of bromine

[1]

/4

Source: Learners' Alley, Chemical Energetics I slides

3 COMMON $25.0\ cm^3$ of $1.00\ mol\ dm^{-3}$ HCl is mixed with $25.0\ cm^3$ of $1.00\ mol\ dm^{-3}$ NaOH. The temperature rises by 6.7 °C. Find ΔH_{neut}.

[3]

/3

Source: Learners' Alley, Chemical Energetics I slides

4 Find ΔH for $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$, given ΔH_f / kJ mol^{-1}: C_2H_4 +52, C_2H_6 −85.

[1]

/1

Source: Learners' Alley, Chemical Energetics I slides

5 CHALLENGE In question 4, why is ΔH_f of H_2 not in the sum?

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[1]

/1

Source: Learners' Alley, Chemical Energetics I slides

6 COMMON Find the lattice energy of NaCl, given / kJ mol^{-1}: ΔH_f(NaCl) −411, ΔH_{at}(Na) +107, ΔH_{at}(Cl) +122, IE(Na) +494, EA(Cl) −349.

[2]

/2

Source: Learners' Alley, Chemical Energetics I slides

7 CHALLENGE Why is ΔH_{at}(Cl) half the Cl–Cl bond energy (244 kJ mol^{-1})?

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[1]

/1

Source: Learners' Alley, Chemical Energetics I slides

B Practice

28 MARKS

8 COMMON A student mixes 25.0 cm^3 of 0.350 mol dm^{-3} sodium hydroxide solution with 25.0 cm^3 of 0.350 mol dm^{-3} hydrochloric acid. The temperature increases by 2.5 °C. No heat is lost to the surroundings. The final mixture has a specific heat capacity of 4.2 J g^{-1} K^{-1}. What is the molar enthalpy change for the reaction?

A −150 kJ mol^{-1} **B** −60 kJ mol^{-1} **C** −30 kJ mol^{-1} **D** −0.15 kJ mol^{-1}

Answer [ ] [1]

/1

Source: 2025 ASRJC J2 Prelim P1 Q7

9 Silane, SiH_4, exists as a gas at standard temperature and pressure. Hess' Law can be used to calculate the average Si–H bond energy in gaseous SiH_4. Which information is needed to perform the calculation?

A $\Delta H^{\ominus}_{formation}(SiH_4)$, $\Delta H^{\ominus}_{atomisation}(Si)$, $\Delta H^{\ominus}_{combustion}(H_2)$

B $\Delta H^{\ominus}_{atomisation}(Si)$, $\Delta H^{\ominus}_{atomisation}(H)$, $\Delta H^{\ominus}_{formation}(SiH_4)$

C $\Delta H^{\ominus}_{atomisation}(H)$, $\Delta H^{\ominus}_{combustion}(Si)$, $\Delta H^{\ominus}_{combustion}(SiH_4)$

D $\Delta H^{\ominus}_{combustion}(Si)$, $\Delta H^{\ominus}_{combustion}(H_2)$, $\Delta H^{\ominus}_{formation}(SiH_4)$

Answer [ ] [1]

/1

Source: 2025 ASRJC J2 Prelim P1 Q8

10 COMMON Which of the compounds Na_2O, MgO, NaCl and $MgCl_2$ would have the largest lattice energy in magnitude? Explain your choice.

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..... **[2]**

/2

Source: EJC 2022 JC1 Chemical Energetics Tutorial, A5

11 In determining the enthalpy change of combustion of glucose, $C_6H_{12}O_6$, using a bomb calorimeter, the following results were obtained.

heat capacity of the calorimeter	765 J K^{-1}	**mass of glucose burnt**	2.18 g
specific heat capacity of water	4.2 J g^{-1} K^{-1}	**mass of water in calorimeter**	1750 g
initial temperature of water and calorimeter	17.84 °C	**final temperature of water and calorimeter**	21.10 °C

(a) What do you understand by the term enthalpy change of combustion?

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..... **[1]**

(b) Calculate the enthalpy change of combustion of glucose.

[3]

/4

Source: EJC 2022 JC1 Chemical Energetics Tutorial, B1

12 Dinitrogen pentoxide, N_2O_5, can be produced by the following reaction sequence.

I	$N_2(g) + O_2(g) \rightarrow 2NO(g)$	$\Delta H = +180\ kJ\ mol^{-1}$
II	$NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g)$	$\Delta H = -57\ kJ\ mol^{-1}$
III	$2NO_2(g) + \frac{1}{2}O_2(g) \rightarrow N_2O_5(g)$	$\Delta H = -55\ kJ\ mol^{-1}$

(a) Suggest why reaction I is endothermic.

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..... **[1]**

(b)(i) What is meant by the standard enthalpy change of formation of a compound?

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..... **[1]**

(ii) Write an equation which corresponds to the enthalpy change of formation of dinitrogen pentoxide.

..... **[1]**

(iii) Use the data given to calculate the enthalpy change of formation of dinitrogen pentoxide.

[2]

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Source: EJC 2022 JC1 Chemical Energetics Tutorial, B4(a)(ii) and (b)

13 Nitroglycerin, $C_3H_5(NO_3)_3$, is a flammable liquid commonly used to manufacture dynamite. Upon ignition, nitroglycerin decomposes to produce nitrogen, oxygen, carbon dioxide and steam.

	nitroglycerin(l)	$H_2O(g)$	$CO_2(g)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	−364	−242	−394

(a) Write a balanced equation, with state symbols, for the decomposition of 1 mol of liquid nitroglycerin.

..... **[1]**

(b) With reference to the above data, calculate the standard enthalpy change of decomposition of 1 mol of nitroglycerin.

[1]

/2

Source: 2019 CJC J1 Promo P2 Q4(a) and (b)

14 COMMON Iron(II) compounds are generally only stable in neutral, non-oxidising conditions. It is difficult to determine the lattice energy of FeO experimentally.

	ΔH / kJ mol^{-1}
enthalpy change of atomisation of Fe(s)	+416
sum of first and second electron affinity of O(g)	+657
enthalpy change of formation of FeO(s)	−272

Data Booklet values: first and second ionisation energies of Fe are +762 and +1560 kJ mol^{-1}, the O=O bond energy is +496 kJ mol^{-1}, and the ionic radii of Fe^{2+} and Ca^{2+} are 0.061 nm and 0.099 nm.

(a) Use the data above to construct a labelled Born–Haber cycle to determine the lattice energy of FeO(s).

[3]

(b) State and explain how the lattice energy of FeO(s) compares to the lattice energy of CaO(s).

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Source: 2023 SAJC J2 Prelim P2 Q2(c)(i) and (ii)

15 **CHALLENGE** Assume that the specific heat capacity and density of all solutions are 4.18 J g^{-1} K^{-1} and 1.00 g cm^{-3} respectively.

(a) When 2.76 g of potassium carbonate was added to 30.0 cm^3 of approximately 2 mol dm^{-3} hydrochloric acid, the temperature rose by 5.20 °C.

(i) Write an equation for this reaction.

..... **[1]**

(ii) Calculate the enthalpy change for this reaction per mole of potassium carbonate.

[2]

(b) When 2.00 g of potassium hydrogen carbonate was added to 30.0 cm^3 of the same hydrochloric acid, the temperature fell by 3.70 °C.

(i) Write an equation for this reaction.

..... **[1]**

(ii) Calculate the enthalpy change for this reaction per mole of potassium hydrogen carbonate.

[2]

(c) When potassium hydrogen carbonate is heated, it decomposes into potassium carbonate, carbon dioxide and water. By applying Hess' Law and your results in (a) and (b), calculate the enthalpy change for the decomposition of potassium hydrogen carbonate.

[2]

/8

Source: RJC H2 Chemistry Tutorial 5a (Chemical Energetics I), Q3