Revision Sheet

A-Level Chemistry · Unit 23 Chemical energetics

6 vocabulary items · 47 marks of exam questions (4 questions)

Part 1 · Vocabulary review (6 items). The terms this unit is examined on most. Mark it yourself from the answer key.

Section A · Chinese to English

Write the English word.

1. _____ [1]

2. _____ [1]

3. _____ [1]

4. _____ [1]

5. _____ [1]

6. _____ [1]

Part 2 · Exam questions (47 marks, 4 questions) begins on the next page. They are ordered easy to difficult and none of them has been set before.

7 (a) (i) Define first electron affinity.

.....

.....

..... [2]

(ii) The first electron affinity of an atom is usually an exothermic process, whereas the second electron affinity is an endothermic process.

Suggest why.

.....

..... [1]

(iii) Describe the general trend in first electron affinities for C*l*, Br and I. Explain your answer.

.....

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..... [2]

(b) Table 3.1 shows energy changes to be used in this question and in **(c)**.

Table 3.1

energy change	value / kJ mol^{-1}
standard enthalpy change of atomisation of zinc	+131
first ionisation energy of zinc	+906
second ionisation energy of zinc	+1733
standard enthalpy change of formation of $ZnI_2(s)$	–208
lattice energy, $\Delta H^{\ominus}_{latt}$, of zinc iodide, $ZnI_2(s)$	–2605
first ionisation energy of iodine	+1008
second ionisation energy of iodine	+1846
I–I bond energy	+151
enthalpy change of sublimation of iodine, $I_2(s) \rightarrow I_2(g)$	+62

Calculate the first electron affinity for iodine. Use relevant data from Table 3.1 in your working.
It may be helpful to draw a labelled energy cycle.
Show all working.

first electron affinity for iodine = ... kJ mol^{-1} [3]

(c) Predict how $\Delta H^{\ominus}_{latt}$ of $CdI_2(s)$ differs from $\Delta H^{\ominus}_{latt}$ of $ZnI_2(s)$.
Place a tick (✓) in the appropriate box in Table 3.2.

Table 3.2

$\Delta H^{\ominus}_{latt}$ of $CdI_2(s)$ is less negative than $\Delta H^{\ominus}_{latt}$ of $ZnI_2(s)$	$\Delta H^{\ominus}_{latt}$ of $CdI_2(s)$ is the same as $\Delta H^{\ominus}_{latt}$ of $ZnI_2(s)$	$\Delta H^{\ominus}_{latt}$ of $CdI_2(s)$ is more negative than $\Delta H^{\ominus}_{latt}$ of $ZnI_2(s)$

Explain your answer.

.....

..... [1]

[Total: 9]

8 **(a)** Complete Table 3.1 by placing **one** tick (✓) in each row to indicate the sign of each type of energy change under standard conditions.

Table 3.1

energy change	always positive	always negative	can be either negative or positive
bond energy			
enthalpy change of atomisation			
enthalpy change of formation			

[1]

(b) Define standard enthalpy change of atomisation.

.....

.....

..... [2]

(c) Table 3.2 shows some energy changes.

Table 3.2

energy change	value / kJ mol^{-1}
standard enthalpy change of atomisation of silver	+285
first ionisation energy of silver	+731
second ionisation energy of silver	+2074
bond energy of O=O	+496
bond energy of O–O	+150
first electron affinity of oxygen	–141
second electron affinity of oxygen	+798
first ionisation energy of oxygen	+1314
standard enthalpy change of formation of silver oxide, $Ag_2O(s)$	–31

Calculate the lattice energy, $\Delta H^{\ominus}_{latt}$, of $Ag_2O(s)$ using relevant data from Table 3.2.

It may be helpful to draw a labelled energy cycle.

Show your working.

$\Delta H^{\ominus}_{latt}$ of $Ag_2O(s)$ = ... kJ mol^{-1} [3]

(d) Suggest the trend in the magnitude of the lattice energies of the silver compounds Ag_2S, Ag_2O and Ag_2Se.

Explain your answer.

....
least exothermic most exothermic

.....

.....

.....
[2]

(e) Silver sulfite, $Ag_2SO_3(s)$, is sparingly soluble in water.

(i) Give an expression for the solubility product, K_{sp}, of Ag_2SO_3.

K_{sp} =

[1]

(ii) Calculate the equilibrium concentration of Ag^+ in a saturated solution of Ag_2SO_3 at 298 K.

[K_{sp}: Ag_2SO_3, 1.50×10^{-14} mol^3 dm^{-9} at 298 K]

[Ag^+] = ... mol dm^{-3} [1]

(f) The standard enthalpy change of solution, $\Delta H^{\ominus}_{sol}$, of $AgNO_3(s)$ in water is +22.6 kJ mol^{-1}.

Suggest how the feasibility of dissolving $AgNO_3(s)$ in water changes with temperature.

Explain your answer.

.....

.....

.....

..... [2]

[Total: 12]

9 **(a)** Describe the trend in the solubility of the sulfates of magnesium, calcium and strontium.

Explain your answer.

..... > ..... > .....
most soluble least soluble

.....

.....

.....

.....

.....

..... [4]

(b) Define lattice energy, ΔH_{latt}.

.....

..... [2]

(c) State and explain the main factors that affect the magnitude of lattice energies.

.....

.....

.....

.....

..... [2]

(d) Table 1.1 shows some energy changes.

Table 1.1

energy change	value / kJ mol^{-1}
standard enthalpy change of atomisation of potassium	+89
first ionisation energy of potassium	+419
second ionisation energy of potassium	+3070
standard enthalpy change of atomisation of sulfur	+279
S–S bond energy	+265
first ionisation energy of sulfur	+1000
second ionisation energy of sulfur	+2260
first electron affinity of sulfur	–200
second electron affinity of sulfur	+640
standard enthalpy change of formation of potassium sulfide, $K_2S(s)$	381

(i) Born–Haber cycles can be used to determine the lattice energies of ionic compounds.

Complete the Born–Haber cycle in Fig. 1.1 for potassium sulfide, $K_2S(s)$.

Include state symbols for all of the species.

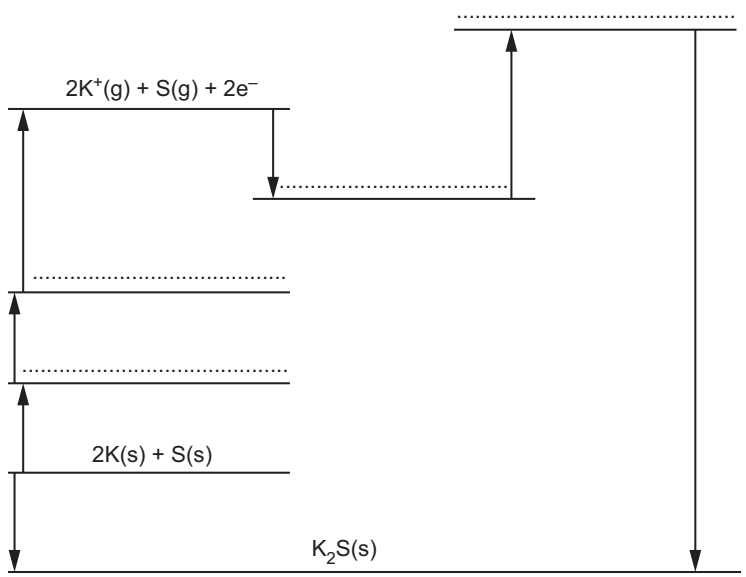

Fig. 1.1

[3]

(ii) Calculate the lattice energy, $\Delta H^{\ominus}_{latt}$, of $K_2S(s)$ using relevant data from Table 1.1.

Show your working.

$\Delta H^{\ominus}_{latt}$ of $K_2S(s)$ = ... kJ mol^{-1} [2]

[Total: 13]

1 Radium is a Group 2 element.

The predicted lattice energy, $\Delta H^{\ominus}_{latt}$, of radium sulfide, RaS, is –2612 kJ mol^{-1}.

(a) Define $\Delta H^{\ominus}_{latt}$.

.....

..... [2]

Some data relating to radium and sulfur are listed. Select relevant data from this list for use in your answers to parts **(b)** to **(e)**.

process	value / kJ mol^{-1}
enthalpy change for $Ra(s) \rightarrow Ra^{2+}(g) + 2e^-$	+1619
first ionisation energy of sulfur	+1000
second ionisation energy of sulfur	+2260
first electron affinity of sulfur	–200
second electron affinity of sulfur	+532
enthalpy change for $\frac{1}{8}S_8(s) + 2e^- \rightarrow S^{2-}(g)$	+555
lattice energy of RaS(s)	–2612

(b) Write an equation for the process corresponding to the **second** electron affinity of sulfur. Include state symbols.

..... [1]

(c) Sulfur exists as S_8 molecules in the solid state.

Use the data in this question to calculate the enthalpy change for the reaction $S_8(s) \rightarrow 8S(g)$.

enthalpy change = ... kJ mol^{-1} [3]

(d) Calculate the standard enthalpy change of formation, $\Delta H^{\ominus}_{f}$, of radium sulfide.

standard enthalpy change, $\Delta H^{\ominus}_{f}$ = ... kJ mol^{-1} [2]

(e) **(i)** State the **two** major factors that affect the numerical magnitude of a lattice energy.

.....

..... [2]

(ii) For **each** factor you have identified in **(e)(i)**, state whether it tends to make the lattice energy of radium sulfide more or less exothermic than that of sodium chloride.

Explain your answer.

.....

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.....

..... [2]

(iii) The lattice energies of sodium chloride, NaC*l*, and radium sulfide, RaS, are –771 kJ mol^{-1} and –2612 kJ mol^{-1}, respectively.

Identify the **dominant** factor in determining the relative numerical magnitudes of the lattice energies of radium sulfide and sodium chloride.

Explain your answer.

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..... [1]

[Total: 13]