

Past-paper walk-through

Lattice energy and Born-Haber cycles ■ 23.1

eXercise

Questions in this set

- 9701/42 N25 Q4 ■ 6 marks
- 9701/44 N25 Q2 ■ 18 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- **//** separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = “or words to that effect” – the wording need not match.

Question 4

9701/42 N25 ■ Q4 ■ 6 marks

- 4 (a)** Define enthalpy change of atomisation, ΔH_{at} .

Question 4

(b) Define first electron affinity, EA.

Question 4

- (c) Explain why the first electron affinity of chlorine is more exothermic than the first electron affinity of iodine.

Question 4

(d) The enthalpy change for the reaction $\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{g})$ is -486 kJ mol^{-1} .

The first electron affinity of chlorine is -364 kJ mol^{-1} .

Calculate the enthalpy change of atomisation of chlorine.

Question 4

[Total: 6]

Solution 4

(a)

Mark scheme

- energy required when one mole of gaseous atoms is formed from the element
- 1

Solution 4

(b)

Mark scheme

- energy released when one mole of gaseous atoms gains one mole of electrons and becomes one mole of gaseous 1^- ions
- 1

Solution 4

(c)

Mark scheme

- M1: iodine atom has greater radius
- M2: less attraction between nucleus and incoming electron in iodine
- 2

Solution 4

(d)

Mark scheme

- M1: $\frac{1}{2} (-486 + (2 \times 364))$
- M2: +121
- 2

Question 2

9701/44 N25 ■ Q2 ■ 18 marks

- 2 (a)** The Group 2 sulfates and the Group 2 chromates show similar trends in solubility.

Suggest the trend in the solubility of the Group 2 chromates down the group.

Explain your answer.

Question 2

(b) Silver(I) chromate, Ag_2CrO_4 , is sparingly soluble in water.

(i) Write an ionic equation to show the equilibrium between solid Ag_2CrO_4 and its aqueous solution.

Include state symbols.

Question 2

- (ii) The value of the solubility product, K_{sp} , of Ag_2CrO_4 is 1.12×10^{-12} at 298 K.

Calculate the equilibrium concentration of Ag^+ , in mol dm^{-3} , in a saturated solution of Ag_2CrO_4 at 298 K.

Question 2

Question 2

Question 2

- (c) The hydrogenchromate ion, HCrO_4^- , is a weak acid. The $\text{p}K_{\text{a}}$ of HCrO_4^- is 6.49.
- (i) Calculate the pH of a $0.0250 \text{ mol dm}^{-3}$ HCrO_4^- solution.

Question 2

(ii) HCrO_4^- can show amphoteric behaviour.

State the formula of:

Question 2

Question 2

[1]

(d) Table 2.1 shows some energy changes.

Table 2.1

energy change	value / kJ mol^{-1}
first ionisation energy of silver	+731
second ionisation energy of silver	+2074
first ionisation energy of sulfur	+1000
second ionisation energy of sulfur	+2251
first electron affinity of sulfur	-200
second electron affinity of sulfur	+532
enthalpy change of atomisation of sulfur	+279

Question 2



Question 2

enthalpy change of formation of silver(I) sulfide, $\text{Ag}_2\text{S}(\text{s})$	-33
lattice energy of silver(I) sulfide, $\text{Ag}_2\text{S}(\text{s})$	-2677

- (i) Define the term first electron affinity.

Question 2

- (ii) Explain why the value for the second electron affinity of sulfur is positive.

Question 2

(iii) Construct an equation for the lattice energy of Ag_2S .

Include state symbols.

Question 2

- (iv) Calculate the enthalpy change of atomisation, ΔH_{at} , in kJ mol^{-1} , of silver using relevant data from Table 2.1.

It may be helpful to draw a labelled Born–Haber cycle.

Show your working.

Question 2

Question 2

- (e) Suggest how the magnitude for the lattice energy of $\text{Ag}_2\text{S(s)}$ differs from the lattice energy of $\text{Cu}_2\text{S(s)}$.

Explain your answer.

Question 2

[Total: 18]

Solution 2

(a)

Mark scheme

- M1: (solubility) decreases down the group
- M2: ΔH_{latt} and ΔH_{hyd} decrease / become less exothermic / less negative
- M3: ΔH_{hyd} decreases / changes more / dominant factor / becomes less exothermic by a larger extent
- OR ΔH_{latt} decreases / changes less / changes slower
- M4: ΔH_{sol} becomes less exothermic / less negative OR ΔH_{sol} becomes (more) endothermic / (more) positive
- 4

Solution 2

(b)(i)

Mark scheme

- $\text{Ag}_2\text{CrO}_4(\text{s}) \rightarrow 2\text{Ag}^+(\text{aq}) + \text{CrO}_4^{2-}(\text{aq})$
- 1

Solution 2

(b)(ii) Mark scheme

- M1: $K_{sp} = [\text{Ag}^+]^2 [\text{CrO}_4^{2-}]$
- M2: $\sqrt{(1.12 \times 10^{-12} \div 4)}$
- 3
- $= 6.54 \times 10^{-5}$
- M3: $[\text{Ag}^+] = 2 \times 6.54 \times 10^{-5} = 1.31 \times 10^{-4} \text{ (mol dm}^{-3}\text{) min 2sf}$
- 3
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Solution 2

(c)(i)

Mark scheme

- $K_a = 10^{-6.49} = 3.236 \times 10^{-7}$

H^+ $2 = 8.08984 \times 10^{-9}$

- M1: $[H^+] = 8.99 \times 10^{-5}$

- M2: $pH = -\log(8.99 \times 10^{-5}) = 4.05$ min 2sf

- 2

Solution 2

(c)(ii)

Mark scheme

- conjugate acid
- H_2CrO_4
- AND
- conjugate base
- CrO_4^{2-}
- 1

Solution 2

(d)(i)

Mark scheme

- (the energy change / released when) one mole of gaseous atoms become 1- ions / gain one mole of electrons
- 1

(d)(ii)

Mark scheme

- due to repulsion between negative ion and incoming / gained electron
- 1

Solution 2

(d)(iii)

Mark scheme

- $2\text{Ag}^+(\text{g}) + \text{S}^{2-}(\text{g}) \rightarrow \text{Ag}_2\text{S}(\text{s})$
- 1

Solution 2

(d)(iv) Mark scheme

- M1: selection of correct six numbers only: -33 , 731 , 279 , -200 , 532 , -2677
- M2: use of $\times 2$ as only multiplier with ΔH_{at}
- M3: correct signs and evaluation of data
- $-33 = 2\Delta H_{\text{at}} + (2 \times 731) + 279 + (-200) + 532 + (-2677)$
- $2\Delta H_{\text{at}} = 571 \text{ (kJ mol}^{-1}\text{)}$
- $\Delta H_{\text{at}} = +285.5 \text{ (kJ mol}^{-1}\text{)}$
- 3

Solution 2

(e)

Mark scheme

- Ag₂S smaller / less negative / less exothermic lattice neergy AND larger ionic radius (of cation)
- 1
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