

Thermodynamics – A2 Chemistry P1 & P3

1. No.8

0 8

This question is about enthalpy changes.

0 8 . 1

Theoretical values for enthalpies of lattice dissociation can be calculated using a perfect ionic model.

State the meaning of the term perfect ionic model.

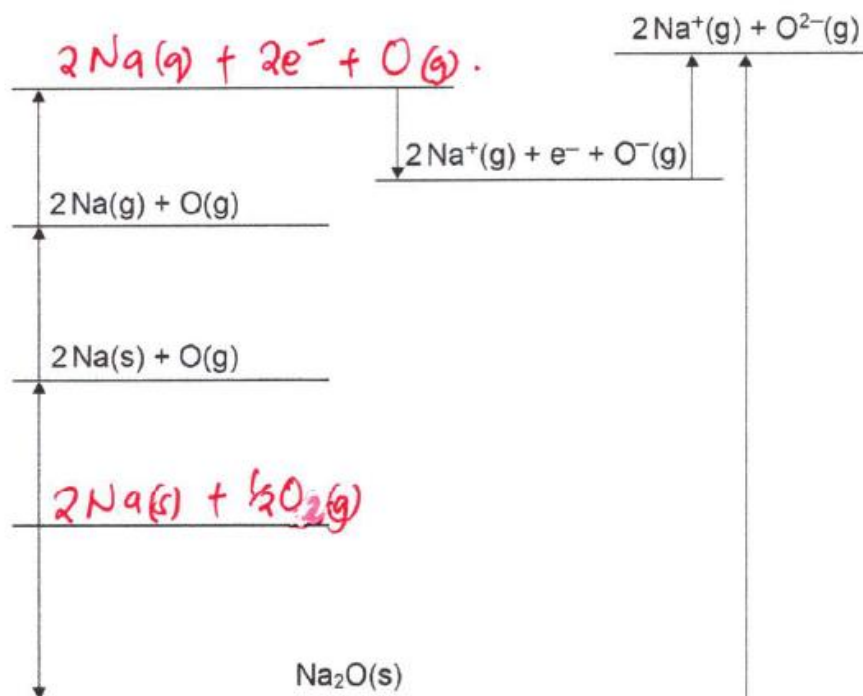
[1 mark]

ions are point charges with perfect spheres and have no covalent character.

0 8 . 2

Enthalpies of lattice dissociation can also be obtained from Born–Haber cycles.

Figure 3 shows an incomplete Born–Haber cycle for the formation of sodium oxide.

Figure 3

Complete **Figure 3** by writing formulas, including state symbols, of the appropriate species on each of the two blank lines.

[2 marks]

0 8 3 Table 4 shows some enthalpy changes.

Table 4

Enthalpy change	$\Delta H / \text{kJ mol}^{-1}$
Enthalpy of atomisation of oxygen	+248
Enthalpy of atomisation of sodium	+109
Enthalpy of formation of sodium oxide	-416
First ionisation energy of sodium	+494
First electron affinity of oxygen	-142
Second electron affinity of oxygen	+844

Use the data in Table 4 to calculate the enthalpy of lattice dissociation of sodium oxide.

[2 marks]

$$\begin{aligned}
 -416 + x &= 248 + (2 \times 109) + (2 \times 494) - 142 + 844 \\
 x &= 2572
 \end{aligned}$$

Enthalpy of lattice dissociation + 2572. kJ mol⁻¹

0 8 4 Explain why the second electron affinity of oxygen has a positive value.

[1 mark]

The O^- ion repels the incoming electron, so energy must be supplied to overcome repulsion.

0 8 . 5

Explain why the enthalpy of lattice dissociation for sodium oxide is greater than the enthalpy of lattice dissociation for sodium chloride.

[2 marks]

Oxides have higher charge of 2- and smaller size compared to chloride ion -1. This gives a higher charge density and stronger electrostatic attraction to Na^+ ions.

0 8 . 6

Sodium chloride dissolves in water.

Table 5 shows some more enthalpy changes.

Table 5

Enthalpy change	$\Delta H / \text{kJ mol}^{-1}$
Enthalpy of hydration for Cl^- ions	-364
Enthalpy of hydration for Na^+ ions	-406
Enthalpy of lattice dissociation for NaCl	+771

Use the data in Table 5 to calculate the enthalpy of solution for sodium chloride.

[2 marks]

$$\Delta H_{\text{solution}} = +771 - 406 - 364.$$

$$= +1 \text{ kJ mol}^{-1}$$

Enthalpy of solution +1 kJ mol^{-1}

08.7

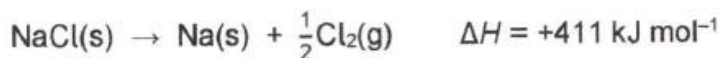
Give a reason why data books do **not** contain a value for the enthalpy of solution of sodium oxide.

[1 mark]

Na₂O reacts with water to form aqueous sodium hydroxide.

08.8

Calculate the temperature, in °C, at which this reaction becomes feasible.



$$\Delta S = +90.1 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$\Delta H = +411 \text{ kJ mol}^{-1} = 411000 \text{ J mol}^{-1}$$

[3 marks]

$$T = \frac{\Delta H}{\Delta S} = \frac{411000}{90.1} = 4562 \text{ K.}$$

Convert to °C.

$$= 4562 - 273$$

$$= 4289$$

Temperature 4289 °C

2. No.9

0 9

This question is about metals and their compounds.

0 9 . 1

State why the atomic radius of calcium is greater than the atomic radius of magnesium.

[1 mark]

Calcium has more energy levels than magnesium.

0 9 . 2

Magnesium reacts with steam.

Give an equation, including state symbols, for this reaction.

[1 mark]



0 9 . 3

Similar-sized pieces of barium and magnesium are added to separate 100 cm³ samples of dilute sulfuric acid. In each case the sulfuric acid is in excess.

The barium reacts quickly at first. After a few minutes the reaction stops, even though there is still some unreacted barium in the flask.

The magnesium reacts more slowly than the barium, but the reaction continues until all the magnesium has reacted.

Explain why

- the barium initially reacts more quickly than the magnesium
- the barium reaction stops before all the barium has reacted.

[3 marks]

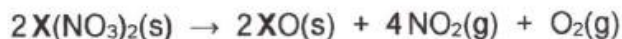
Barium is more reactive because its outer electrons are further from the nucleus, so they are lost more easily.

It forms an insoluble sulfate.



The barium sulfate forms a coating, preventing further reaction.

09.4

A metal nitrate $X(NO_3)_2$ completely decomposes when heated.

A 0.832 g sample of $X(NO_3)_2$ decomposes on heating to produce a total of 348 cm³ of gas at 298 K and 100 kPa

Deduce the identity of metal X.

The ideal gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

[6 marks]

$$P = 100000 \text{ Pa} \quad V = 348 \times 10^{-6} \text{ m}^3$$

$$n_{\text{total gas}} = \frac{PV}{RT} = \frac{100000 \times 348 \times 10^{-6}}{8.31 \times 298} = 0.01405 \text{ mol.}$$

Each mole of $X(NO_3)_2$ gives 2.5 moles of gas.

$$n_{X(NO_3)_2} = \frac{0.01405}{2.5} = 5.62 \times 10^{-3} \text{ mol.}$$

$$M_r = \frac{0.832}{5.62 \times 10^{-3}} = 148.0$$

$$\text{Mass of nitrate} = (2 \times 14) + (6 \times 16) = 124$$

$$\text{Ar of X} = 148.0 - 124.0 = 24.0$$

$$X = \text{Mg.}$$

Identity of metal X Mg.

09.5

Sodium reacts with aluminium and hydrogen to form solid NaAlH_4

Give an equation for this reaction.

Suggest why NaAlH_4 has a high melting point.

[3 marks]

Equation



Suggestion It contains oppositely charged ions (Na^+ and AlH_4^-). These ions are held together by strong electrostatic forces of attraction.

09.6

Give the equation for the reaction between H_3PO_4 and an excess of NaOH

[1 mark]



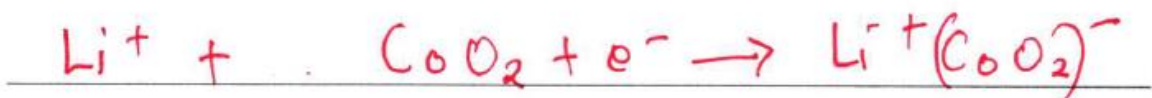
Lithium is an important metal used in cells to power mobile phones.

09.7

In a lithium cell, a lithium cobalt oxide electrode and a lithium electrode are used.

Give the equation for the reaction that occurs at the positive electrode.

[1 mark]



09.8

Commercial electrochemical cells can be rechargeable or non-rechargeable.

State why lithium cells can be recharged.

[1 mark]

The electrode reactions are reversible when an external voltage is applied

3. No.16

Which statement explains why the rate of a reaction increases when a catalyst is added at a constant temperature?

[1 mark]

catalyst does not influence/affect.

A The collision frequency increases because there is a decrease in activation energy. ☐

collision frequency remains unaffected by catalyst.

B The collision frequency increases because there is an increase in the average energy of the particles. ☐

C The proportion of successful collisions increases because there is a decrease in activation energy. *that have enough energy to be successful* ☐

D The proportion of successful collisions increases because there is an increase in the average energy of the particles. *Does not affect average energy.* ☐