

# Basic Calculations

## Question Paper 1

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Basic Calculations-Physical Chemistry
Booklet	Question Paper 1

**Time Allowed:** 34 minutes

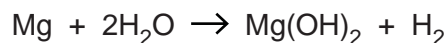
**Score:** /28

**Percentage:** /100

**Grade Boundaries:**

1. Magnesium powder is used to generate heat for battlefield soldiers wanting a hot drink.

9.0g of magnesium powder is added to 30.0g, an excess, of water.



- (a) Calculate the amount, in mol, of magnesium.

..... mol [1]

- (b) Calculate the mass of water that is in excess.

..... g [2]

- (c) Calculate the volume of hydrogen gas, in  $\text{dm}^3$ , produced at room temperature and pressure.

.....  $\text{dm}^3$  [1]

- (d) Use the standard enthalpy change of formation data in the table to calculate the standard enthalpy change of reaction for magnesium reacting with water.

substance	$\Delta_f H^\ominus / \text{kJ mol}^{-1}$
$\text{H}_2\text{O}$	-285.8
$\text{Mg}(\text{OH})_2$	-924.5

.....  $\text{kJ mol}^{-1}$  [2]

- (e) Calculate the heat energy, in kJ, released when 9.0 g of magnesium powder is added to 30.0 g of water.

..... kJ [1]

- (f) When the magnesium powder and water are mixed, the temperature of the drink being heated can rise to 60°C in about 10 minutes.

Calculate how much energy, in kJ, is required to heat 150 g of the drink from 15°C to 60°C. Assume that the specific heat capacity of the drink is  $4.2 \text{ J g}^{-1} \text{ K}^{-1}$ .

..... kJ [1]

- (g) How would using 9.0 g of magnesium **granules** affect the amount of energy released, and the temperature reached by the drink? Explain your answer.

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

- (h) Exothermic reactions that do **not** produce hydrogen gas are being explored.

- (i) One example is mixing calcium oxide with water. Write an equation for this reaction and give the approximate pH of the resulting solution.

..... pH..... [2]

- (ii) Another example is the reaction of phosphorus(V) oxide with water. Write an equation for this reaction and give the approximate pH of the resulting solution.

..... pH..... [2]

- (iii) Calcium oxide reacts with phosphorus(V) oxide to make calcium phosphate(V). Write an equation for this reaction.

..... [1]

**[Total: 15]**

2. (a) Chemists have recently established that four molecules of water are required for the dissociation of a single molecule of  $\text{HCl}$  (reported in *Science*, 2009).

Given that  $1.00\text{dm}^3$  of water contains  $55.6\text{mol}$  of  $\text{H}_2\text{O}$ , calculate the maximum mass of hydrogen chloride,  $\text{HCl}$ , that should therefore dissociate in  $1.00\text{dm}^3$  of water.

..... g [1]

- (b) Commercial concentrated hydrochloric acid,  $\text{HCl}(\text{aq})$ , fumes strongly on exposure to moist air and so is also known as ‘fuming hydrochloric acid’.

$1.00\text{cm}^3$  of fuming hydrochloric acid was transferred with a graduated pipette to a  $100\text{cm}^3$  volumetric flask. The volume was made up to  $100\text{cm}^3$  with deionised water. The solution was labelled **F**.  $10.0\text{cm}^3$  of solution **F** was neutralised by  $24.75\text{cm}^3$  of  $0.0500\text{mol dm}^{-3}$  of aqueous sodium hydroxide.

Calculate the concentration of  $\text{HCl}$  in the fuming hydrochloric acid in  $\text{mol dm}^{-3}$ . Give your final answer to **three** significant figures.

.....  $\text{mol dm}^{-3}$  [4]

(c) Historically, hydrochloric acid,  $\text{HCl}(\text{aq})$ , was produced by mixing concentrated sulfuric acid with sodium chloride and dissolving the gas produced in water.

(i) Write an equation for the production of gaseous hydrogen chloride by this method.

.....[1]

Hydrobromic acid,  $\text{HBr}(\text{aq})$ , cannot be prepared in the same way as hydrochloric acid because a redox reaction occurs between hydrogen bromide and sulfuric acid.

(ii) Write a balanced equation for the reaction of hydrogen bromide with sulfuric acid.

..... [1]

(iii) Identify the oxidising agent in the reaction. Justify your answer using oxidation numbers.

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

(d) (i) State and explain the trend in bond strength for the gases hydrogen chloride, hydrogen bromide and hydrogen iodide, in that order.

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

(ii) State and explain the trend in acidic strength of hydrochloric acid, hydrobromic acid and hydroiodic acid.

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

(iii) Describe and explain the variation in boiling point of the gases hydrogen fluoride, hydrogen chloride, hydrogen bromide and hydrogen iodide.

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

[Total: 13]