Revision PPQu – Unit 3: Moles and Calculations

1. A student adds 2.12 g of sodium carbonate to an excess of dilute hydrochloric acid.
   The chemical equation for the reaction is

   $$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$
   $$1 : 2 : 2 : 1 : 1$$

   Calculate the maximum mass, in g, of carbon dioxide formed in the reaction. (3)

RFM Na_2CO_3 = $23\times2 + 12 + 16\times3 = 106$ (1)

mol Na_2CO_3 = $\frac{mass}{RFM} = \frac{2.12}{106} = 0.02$ (1)

Ratio $Na_2CO_3 : CO_2 = 1:1 \rightarrow$ 0.02 mol CO_2

RFM $CO_2 = 12 + 16\times2 = 44$

mass CO_2 = mol × RFM = $0.02\times44 = 0.88$ (1)

mass = ... 0.88 ..... g

(Total marks for question = 3)

2. Compound Z contains 38.7% carbon, 9.7% hydrogen and 51.6% oxygen by mass.

(i) Show by calculation that the empirical formula of compound Z is CH_3O (2)

	C	H	O	
mass	38.7	9.7	51.6	
Mr	12	1	16	(1)
mol	3.225	9.7	3.225	
Ratio	1	3	1	(1)

(ii) The relative formula mass (M_r) of compound Z is 62
Deduce the molecular formula of compound Z. (2)

Mr of emp form = 12+3+16 = 31 (1)

62 ÷ 31 = 2 so molecular formula is 2x empirical formula

molecular formula = $C_2H_6O_2$ (1)

(Total for question = 4 marks)

3.

(a) A student produces dry crystals of hydrated copper(II) sulfate from a saturated solution of copper(II) sulfate.
He calculates that 6.40 g of dry crystals should be formed.
The mass of dry crystals he actually obtains is 1.80 g less than he calculated.
Calculate the student's percentage yield.
Give your answer to one decimal place. (3)

Actual mass formed = 6·40 − 1·80 = 4·6 g (1)

% yield = $\frac{\text{actual yield}}{\text{theoretical yield}} \times 100$

= $\frac{4·6}{6·4} \times 100 = 71·875$ (1)

percentage yield = ... 71·9 (1) ..... %

(b) Gypsum is hydrated calcium sulfate.
A sample of gypsum contains 79% of calcium sulfate by mass.
Calculate the value of x in $CaSO_4.xH_2O$
[M_r of $CaSO_4$ = 136 M_r of H_2O = 18] (3)

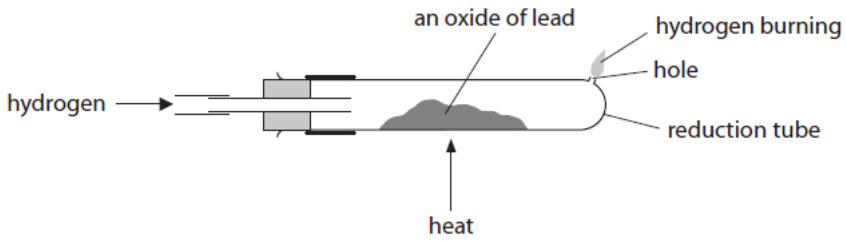
	$CaSO_4$	H_2O
Mass	79	(100 − 79 =) 21 (1)
Mr	136	18
Mol	0.58...	1.16... (1)
Ratio	1	2.00... → 2

x = ... 2 (1) .....

(Total marks for question = 6)

4.

(a) The diagram shows the apparatus a teacher uses to determine the formula of an oxide of lead.



This is the teacher's method.

Step 1 find the mass of the reduction tube
Step 2 add some of the lead oxide to the reduction tube
Step 3 find the mass of the reduction tube and lead oxide
Step 4 pass hydrogen gas over the lead oxide and ignite the hydrogen at the hole
Step 5 heat the lead oxide strongly for 10 minutes
Step 6 keep passing hydrogen through the reduction tube until the tube and contents are cool
Step 7 find the new mass of the reduction tube and its contents

(i) Give a reason why hydrogen is passed through the reduction tube until the tube and contents are cool. (1)

So the lead doesn't react with oxygen again.

(ii) Describe what the teacher should do next to make sure all the lead oxide has been reduced to lead. (2)

• Repeat the heating & weighing process
• Until the mass stays the same

"Heat to constant mass" for 2 marks

(b) The teacher completes the experiment and obtains these results.

mass of reduction tube = 23.50 g
mass of tube + lead oxide = 28.64 g
mass of tube + lead = 28.16 g

(i) Calculate the mass of lead formed. (1)

28.16 - 23.50 = 4.66

mass of lead = 4.66 ..... g

(ii) Calculate the mass of oxygen removed from the lead oxide. (1)

28.64 - 28.16 = 0.48

mass of oxygen = 0.48 ..... g

(iii) Determine the empirical formula of the lead oxide. (4)

	Pb	O
Mass	4.66	0.48
RAM	207	16
MOL	0.02...	0.03
Ratio	1	1.33...
	3 (x3)	4 (x3)

empirical formula of the lead oxide Pb_3O_4

(c) The insoluble salt lead(II) chloride ($PbCl_2$) can be prepared by reacting a solution of lead(II) nitrate with dilute hydrochloric acid.

(i) Complete the equation for the reaction by adding the state symbols. (1)

$Pb(NO_3)_2$(aq) + 2HCl(aq) → $PbCl_2$(s) + 2HNO_3(aq)

1 : 2 : 1 : 2

(ii) Show that the maximum mass of lead(II) chloride that can be made from 0.0370 mol of hydrochloric acid is about 5 g.
[M_r of $PbCl_2$ = 278] (3)

Ratio $HCl : PbCl_2 = 2:1 \rightarrow 0.0370 : 0.0185$ (1)

Mass = mol × Mr = 0.0185 × 278 (1)
= 5.143g (1)

maximum mass = 5.143 g

(Total marks for question = 13)

TOTAL MARKS FOR QUESTIONS = 26

EXTENSIONS

1. A sample containing 0.02 moles of hydrated copper(II) sulfate is heated using a Bunsen burner.
   The products of the reaction are anhydrous copper(II) sulfate and water.
   This is the equation for the reaction:
   $CuSO_4.5H_2O \rightarrow CuSO_4 + 5H_2O$

   1 : 1 : 5

   Calculate the maximum number of water molecules in tube B after the sample of hydrated copper(II) sulfate has completed reacted.
   One mole of any substance contains 6×10^{23} particles. (2)

   Ratio $CuSO_4.5H_2O : H_2O = 1:5 \rightarrow 0.02 : 0.1$ (1)

   $0.1 \times 6 \times 10^{23} = 6 \times 10^{22}$

   maximum number of molecules = ... 6×10^{22} .....

2. The equation represents the complete combustion of an alkane.
   C_nH_{2n+2} + oxygen → carbon dioxide + water

   Complete combustion of 0.0100 mol of the alkane produces 2.16 g of water.
   Determine the molecular formula of this alkane.
   [for H_2O, $M_r = 18$] (3)

   mol of $H_2O = \frac{\text{Mass}}{Mr} = \frac{2.16}{18} = 0.12$ mol (1)

   Ratio $C_nH_{2n+2} : H_2O = 0.01 : 0.12$
   $= 1 : 12$

   So $12H_2O \rightarrow 24 \times H$

   $2n+2 = 24 \rightarrow 2n = 22 \rightarrow n = 11$

   molecular formula = ... $C_{11}H_{24}$ .....

3. In experiment, a student adds 0.55 g of zinc to a solution containing 2.50×10^{-2} moles of hydrochloric acid.
= 0.025
Use the equation to show that hydrochloric acid is in excess.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$
1 : 2 : 1 : 1

[Ar of Zn = 65] (2)

Mol of Zn = $\frac{\text{Mass}}{\text{Ar}} = \frac{0.55}{65} = 8.461... \times 10^{-3}$ (1)
$= 0.008461...$

$8.461... \times 10^{-3}$ mol of Zn would react with
$(8.461... \times 10^{-3} \times 2 =)$ 0.0169... mol HCl

0.0169... < 0.025 mol (1)

So HCl is in excess

TOTAL MARKS FOR EXTENSION = 7

OR 0.025 mol HCl would react with $(0.025 \div 2 =)$ 0.0125 mol Zn
0.0125 < 0.008... so Zn is limiting & HCl is in excess
(1)