LIMITING-EXCESS REAGENTS

4.12.1

Chemists use the concept of the mole to calculate the amounts of chemicals involved in a reaction.

(a) Define *mole*.

.....

[1]

(b) 3.0 g of magnesium was added to 12.0 g of ethanoic acid.

$Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$

The mass of one mole of Mg is 24 g.

The mass of one mole of CH_3COOH is 60 g.

(i) Which one, magnesium or ethanoic acid, is in excess? You must show your reasoning.

.....

.....

.....

[3]

(a) Avogadro's Number of particles
or formula mass in grams
or 6×10^{23} particles accept atoms, ions and molecules
or as many particles as there are carbon atoms in 12.00g of ^{12}Ca
ANY one **[1]**

(b) **(i)** moles of Mg = 3/24 = 0.125
moles of CH_3COOH = 12/60 = 0.200
magnesium is in excess

OR 3.0g of magnesium react with 15g of acid
only 12.0 g of acid present
magnesium is in excess **[3]**

(ii) **Mark conseq to (i) but NOT to any simple integer**
moles of H_2 = 0.1 **[1]**

(iii) **Mark conseq to (ii) but NOT to any simple integer**
Volume of hydrogen = 0.1 x 24
= 2.4 dm^3 **[2]**

4.12.2

Quantities of chemicals, expressed in moles, can be used to find the formula of a compound, to establish an equation and to determine reacting masses.

(c) 0.07 moles of silicon reacts with 25 g of bromine.

$$Si + 2Br_2 \longrightarrow SiBr_4$$

(i) Which one is the limiting reagent? Explain your choice.

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.....

.....

.....

..... [3]

(ii) How many moles of $SiBr_4$ are formed?

..... [1]

(i) silicon is limiting reagent [1]
0.07 moles of Si and 25/160 = 0.156 moles of Br_2 [1]
because 0.14 (2 × 0.07) < 0.156 [1]
If 80 used to find moles of Br_2 the mark 1 and 3 still available
arguments based on masses can be used

(ii) 0.07 [1]
NOT ecf

Quantities of chemicals, expressed in moles, can be used to find the formula of a compound, to establish an equation and to determine reacting masses.

(c) 0.08 moles of silicon reacts with 7.2 g of fluorine.

$$Si + 2F_2 \longrightarrow SiF_4$$

(i) Which one is the limiting reagent? Explain your choice.

.....

.....

.....

.....

..... [3]

(ii) How many moles of SiF_4 are formed?

..... [1]

(i) silicon is limiting reagent [1]
0.08 moles of Si and 7.2/38 = 0.189 moles of F_2 [1]
because 0.16 (2 × 0.08) < 0.189 [1]
If 19 used to find moles of F_2 marks 1 and 3 still available
arguments based on masses can be used

(ii) 0.08 [1]
NOT ecf

4.12.4

4.8 g of calcium is added to 3.6 g of water. The following reaction occurs.

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

(i) the number of moles of Ca = ...

the number of moles of H_2O = ... [1]

(ii) Which reagent is in excess? Explain your choice.

.....

..... [2]

iii) Calculate the mass of the reagent named in **(ii)** which remained at the end of the experiment.

.....

..... [1]

(i) 4.8/40 = 0.12 moles of Ca
3.6/18 = 0.2 moles of H_2O **both** correct [1]

(ii) Ca is in excess (**no mark**) (because 0.12 moles of Ca need) 0.24 moles / 4.32g of H_2O to react [1]
there is not enough / there are 0.2 moles / 3.6g of H_2O [1]
or
Ca is in excess (**no mark**) (because 0.2 moles / 3.6g of water will react with) 0.1moles/4.0g of Ca [1]
there is more than that / there are 0.12 moles / 4.8g of Ca [1]
or
Ca is in excess (**no mark**) because the mole ratio Ca:H_2O is 3:5 / mass ratio 4:3 [1]
which is bigger than the required mole ratio of 1:2 / mass ratio 10:9 [1]
or
Ca is in excess (**no mark**) because the mole ratio H_2O:Ca is 5:3 / mass ratio 3:4 [1]
which is smaller than the required mole ratio of 2:1 / mass ratio 9:10 [1]

(iii) $0.02 \times 40 = 0.8$ (g) [1]

4.12.5

A small piece of marble, calcium carbonate, was added to 5 cm^3 of hydrochloric acid at 25 °C. The time taken for the reaction to stop was measured.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) One piece of marble, 0.3 g, was added to 5 cm^3 of hydrochloric acid, concentration 1.00 mol / dm^3. Which reagent is in excess? Give a reason for your choice.

mass of one mole of $CaCO_3$ = 100 g

number of moles of $CaCO_3$ = ...

number of moles of HCl = ...

reagent in excess is .....

reason ..... [4]

(b) Use your answer to **(ii)** to calculate the maximum volume of carbon dioxide produced measured at r.t.p.

..... [1]

(a)
mass of one mole of $CaCO_3$ = 100
number of moles of $CaCO_3$ = 0.3/100 = 0.003 [1]
moles of HCl = 5/1000 x 1 = 0.005 [1]
reagent in excess is $CaCO_3$ [1]
ecf from above
would need 0.006 moles of HCl
or hydrochloric acid only reacts with 0.0025 moles of $CaCO_3$ [1]
NOTE this mark needs to show recognition of the 1:2 ratio

(b)
mark **ecf** to **(ii)**, that is from moles of limiting reagent in **(ii)**
moles of CO_2 = 0.005 x 0.5 x 24 = 0.06 dm^3 [1]
NOT cm^3 unless numerically correct. 60 cm^3
Ignore other units
NOTE If both number of moles integers then no ecf for **(ii)** and **(iii)**

4.12.6

6.0 g of cobalt(II) carbonate was added to 40 cm^3 of hydrochloric acid, concentration 2.0 mol/dm^3. Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.

$$CoCO_3 + 2HCl \rightarrow CoCl_2 + CO_2 + H_2O$$

$$CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$$

Maximum yield

Number of moles of HCl used = ...

Number of moles of $CoCl_2$ formed = ...

Number of moles of $CoCl_2.6H_2O$ formed = ...

Mass of one mole of $CoCl_2.6H_2O$ = 238 g

Maximum yield of $CoCl_2.6H_2O$ = ... g [4]

To show that cobalt(II) carbonate is in excess

Number of moles of HCl used = ... (use value from above)

Mass of one mole of $CoCO_3$ = 119 g

Number of moles of $CoCO_3$ in 6.0 g of cobalt(II) carbonate = ... [1]

Explain why cobalt(II) carbonate is in excess .....

..... [1]

number of moles of HCl used = 0.04 × 2 = 0.08
number of moles $CoCl_2$ formed = 0.04
number of moles $CoCl_2.6H_2O$ formed = 0.04
mass of one mole of $CoCl_2.6H_2O$ = 238 g
maximum yield of $CoCl_2.6H_2O$ = 9.52g [4]
accept 9.5 g
mark ecf to moles of HCl
do **not** mark ecf to integers

to show that cobalt(II) carbonate is in excess

number of moles of HCl used = 0.08 must use value above **ecf**
mass of one mole of $CoCO_3$ = 119g
number of moles of $CoCO_3$ in 6.0g of cobalt(II) carbonate = 6.0/119 = 0.050 [1]
reason why cobalt(II) carbonate is in excess 0.05 > 0.08/2 [1]

4.12.7

20.0 cm^3 of sulfuric acid, concentration 0.30 mol/dm^3, was added to 40 cm^3 of sodium hydroxide, concentration 0.20 mol/dm^3.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(i) How many moles of H_2SO_4 were added? ..... [1]

(ii) How many moles of NaOH were used? ..... [1]

(iii) Which reagent is in excess? Give a reason for your choice.

reagent in excess ..... [1]

reason .....

..... [1]

(iv) Is the pH of the final mixture less than 7, equal to 7 or more than 7?

..... [1]

(i) how many moles of H_2SO_4 were added = 0.02 × 0.3 = 0.006 [1]

(ii) how many moles of NaOH were used = 0.04 × 0.2 = 0.008 [1]

(iii) sulfuric acid [1]
only mark ecf if in accord with 1:2 ratio and with values from **(i)** and **(ii)**.
reason 0.006 > 0.008/2 [1]
for ecf mark candidate must use 1:2 ratio in answer

(iv) less than 7 [1]

4.12.8

Esters, polyesters and fats all contain the ester linkage.

Esters can be made from alcohols and carboxylic acids. For example, the ester ethyl ethanoate can be made by the following reaction.

$$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$$

6.0 g of ethanoic acid, $M_r = 60$, was reacted with 5.5 g of ethanol, $M_r = 46$.
Determine which is the limiting reagent and the maximum yield of ethyl ethanoate, $M_r = 88$.

number of moles of ethanoic acid = ... [1]

number of moles of ethanol = ... [1]

the limiting reagent is ..... [1]

number of moles of ethyl ethanoate formed = ... [1]

maximum yield of ethyl ethanoate = ... [1]

number of moles of ethanoic acid = 0.1	[1]
number of moles of ethanol = 0.12(0)	[1]
the limiting reagent is ethanoic acid	[1]
number of moles of ethyl ethanoate formed = 0.1	[1]
maximum yield of ethyl ethanoate is 8.8 g	[1]

4.12.9

Propanol reacts with methanoic acid to form the ester propyl methanoate.

$$CH_3CH_2CH_2OH + HCOOH \rightarrow HCOOCH_2CH_2CH_3 + H_2O$$

4.0 g of methanoic acid was reacted with 6.0 g of propanol.

(i) Calculate the M_r of methanoic acid = ... [1]

(ii) Calculate the M_r of propanol = ... [1]

(iii) Determine which one is the limiting reagent. Show your reasoning.

.....

.....

..... [2]

(iv) Calculate the maximum yield in grams of propyl methanoate, M_r = 88.

..... [1]

(i)	46;	**1**
(ii)	60;	**1**
(iii)	moles of $CH_3CH_2CH_2OH$ = 0.1; moles of HCOOH = 0.087 (0.09) **and** limiting reagent is methanoic acid;	**2**
(iv)	88 × (mol of limiting reagent in **4(d)(iii)**); expected answer: 88 × 0.087 = 7.65 g;	**1**