

LIMITING-EXCESS REAGENTS

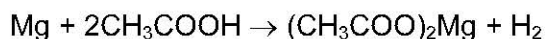
4.12.1

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.



The mass of one mole of Mg is 24 g.

The mass of one mole of CH₃COOH 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 $\text{CH}_3\text{COOH} = 12/60 = 0.200$
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 $\text{H}_2 = 0.1$ [1]

(iii) Mark conseq to (ii) but NOT to any simple integer
Volume of hydrogen = 0.1×24
= 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.



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

.....

.....

.....

.....

..... [3]

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

..... [1]

-----Marking Scheme-----

- (i) silicon is limiting reagent [1]
0.07 moles of Si and $25/160 = 0.156$ moles of Br_2 [1]
because $0.14 (2 \times 0.07) < 0.156$ [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

4.12.3

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.



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

.....

.....

.....

.....

..... [3]

- (ii) How many moles of SiF_4 are formed?

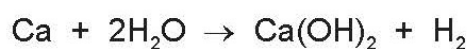
..... [1]

-----Marking Scheme-----

- (i) silicon is limiting reagent [1]
0.08 moles of Si and $7.2/38 = 0.189$ moles of F_2 [1]
because $0.16 (2 \times 0.08) < 0.189$ [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.



(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]

-----Marking Scheme-----

- (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 $\text{Ca}:\text{H}_2\text{O}$ 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 $\text{H}_2\text{O}:\text{Ca}$ 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 cm³ of hydrochloric acid at 25 °C. The time taken for the reaction to stop was measured.



- (a) One piece of marble, 0.3 g, was added to 5 cm³ of hydrochloric acid, concentration 1.00 mol/dm³. Which reagent is in excess? Give a reason for your choice.

mass of one mole of CaCO₃ = 100 g

number of moles of CaCO₃ =

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]

-----Marking Scheme-----

- (a) mass of one mole of $\text{CaCO}_3 = 100$
number of moles of $\text{CaCO}_3 = 0.3/100 = 0.003$ [1]
moles of $\text{HCl} = 5/1000 \times 1 = 0.005$ [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 $\text{CO}_2 = 0.005 \times 0.5 \times 24 = 0.06 \text{ dm}^3$ [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 cm³ of hydrochloric acid, concentration 2.0 mol/dm³. Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.



Maximum yield

Number of moles of HCl used =

Number of moles of CoCl₂ formed =

Number of moles of CoCl₂·6H₂O formed =

Mass of one mole of CoCl₂·6H₂O = 238 g

Maximum yield of CoCl₂·6H₂O = 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 CoCO₃ = 119 g

Number of moles of CoCO₃ in 6.0 g of cobalt(II) carbonate = [1]

Explain why cobalt(II) carbonate is in excess

..... [1]

-----Marking Scheme-----

number of moles of HCl used = $0.04 \times 2 = 0.08$

number of moles CoCl_2 formed = 0.04

number of moles $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ formed = 0.04

mass of one mole of $\text{CoCl}_2 \cdot 6\text{H}_2\text{O} = 238 \text{ g}$

maximum yield of $\text{CoCl}_2 \cdot 6\text{H}_2\text{O} = 9.52\text{g}$

[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 $\text{CoCO}_3 = 119\text{g}$

number of moles of CoCO_3 in 6.0g of cobalt(II) carbonate = $6.0/119 = 0.050$

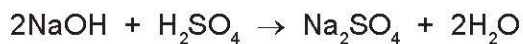
[1]

reason why cobalt(II) carbonate is in excess $0.05 > 0.08/2$

[1]

4.12.7

20.0 cm³ of sulfuric acid, concentration 0.30 mol / dm³, was added to 40 cm³ of sodium hydroxide, concentration 0.20 mol / dm³.



- (i) How many moles of H₂SO₄ 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]

-----Marking Scheme-----

- (i) how many moles of H_2SO_4 were added = $0.02 \times 0.3 = 0.006$ [1]
- (ii) how many moles of NaOH were used = $0.04 \times 0.2 = 0.008$ [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.



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]

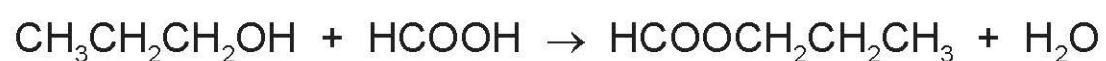
maximum yield of ethyl ethanoate = [1]

-----Marking Scheme-----

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 8.8g	[1]

4.12.9

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



4.0g of methanoic acid was reacted with 6.0g 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 $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} = 0.1$; moles of $\text{HCOOH} = 0.087$ (0.09) and limiting reagent is methanoic acid;	2
(iv)	$88 \times (\text{mol of limiting reagent in 4(d)(iii)})$; expected answer: $88 \times 0.087 = 7.65 \text{ g}$;	1