Suggested Answers on Note (Chapter 10) P.1

Elements	H	C
Relative atomic masses	*1*	*12*
One mole weighs	*1g*	*12g*
Number of atoms in 1 mole	6×10^{23}	6×10^{23}
Number of atoms in 2 mole	$2 \times 6 \times 10^{23}$	$2 \times 6 \times 10^{23}$

Formula	Term to describe its mass	Molecular or Formula mass
H_2O	Molecular / Formula	(1) x 2 + (16) x 1 = 18
$Ca(OH)_2$	Formula	**74**
H_2SO_4	Molecular / Formula	**98**
$Na_2CO_3.10H_2O$	Formula	**286**

Suggested Answers on Note (Chapter 10) P.3

Substance	Symbol / chemical formula	Relative atomic mass(es)	Formula mass / relative molecular mass	Molar mass (mass of 1 mole of substance)
Magnesium	Mg	Mg = 24.3	1 x 24.3 = 24.3	24.3 g mol^{-1}
Nitrogen gas	**N_2**	N = 14.0	**2 x 14.0 = 28.0**	**28.0 g mol^{-1}**
Sulphur dioxide	**SO_2**	O = 16.0 S = 32.1	**2 x 16.0 = 32.0 1 x 32.1 = 32.1 Total =64.1**	**64.1 g mol^{-1}**
Iron(III) sulphate	**$Fe_2(SO_4)_3$**	O = 16.0 S = 32.1 Fe = 55.8	**12 x 16.0 = 192.0 3 x 32.1 = 96.3 2 x 55.8 = 111.6 Total = 399.9**	**399.9 g mol^{-1}**

Examples:

1. **Molar mass of carbon dioxide = 12 + 16 x 2 = 44 g**
   Mass of carbon dioxide = 7.5 x 44
   = 330 g

2. **Number of mole of Mg = 2.4 / 24 = 0.1**
   Number of Mg atom = 0.1 x 6 x 10^{23}
   = 6 x 10^{22}

3. **Number of Na atoms = 1.5 x L**
   = 1.5 x 6 x 10^{23}
   = 9 x 10^{23}

4. **Number of moles of zinc ions = 3 x 10^{24} / 6 x 10^{23}**
   = 5
   There are 5 moles of ions in 3 x 10^{24} zinc ions.

5. (a) **Number of SO_2 molecules = 0.35 x 6 x 10^{23}**
   = 2.1 x 10^{23}

   (b) **One SO_2 molecule contains 1 S atom and 2 O atoms**
   Number of atoms present = 3 x 2.1 x 10^{23}
   = 6.3 x 10^{23}

Suggested Answers on Note (Chapter 10) P.4 – 9

1.

Substance	Chemical formula	Relative atomic masses	Formula mass / relative molecular mass	Molar mass
Hydrogen chloride	**HCl**	H = 1.0 Cl = 35.5	**36.5**	**36.5 g mol^{-1}**
Ethanoic acid	CH_3COOH	H = 1.0 C = 12.0 O = 16.0	**60.0**	**60.0 g mol^{-1}**
Aluminium hydroxide	**$Al(OH)_3$**	H = 1.0 O = 16.0 Al = 27.0	**78.0**	**78.0 g mol^{-1}**
Magnesium carbonate	**$MgCO_3$**	C = 12.0 O = 16.0 Mg = 24.3	**84.3**	**84.3 g mol^{-1}**

2. Number of mole of oxygen = 20 / (16 x 2)
   = 0.625

3. (a) Molar mass of C_xH_{2x} = 210 / 2.5
= 84 g

(b) 84 = 12x + 2x
x = 6
therefore, the chemical formula = C_6H_{12}

4. (a) Number of moles of Cu = 12.7 / 63.5 = 0.2
Number of copper atoms = 0.2 x 6 x 10^{23} = 1.2 x 10^{23}

(b) Number of moles of iron = 3 x 10^{22} / 6 x 10^{23} = 0.05
Mass of iron = 0.05 x 55.8 = 2.79 g

5. (a) no. of moles of ammonia = 0.25
no. of ammonia molecules = 0.25 x 6 x 10^{23} = 1.5 x 10^{23}

(b) One NH_3 molecule contains 1 N atom and 3 H atoms
no. of N atoms = 1.5 x 10^{23}

(c) no. of H atoms = 1.5 x 10^{23} x 3 = 4.5 x 10^{23}

(d) total number of atoms = 1.5 x 10^{23} + 4.5 x 10^{23} = 6 x 10^{23}

6. (a) no. of mole of $MgCl_2$ = 1.2 x 10^{24} / 6 x 10^{23} = 2
mass of $MgCl_2$ = 2 x (24.3 + 35.5 x 2) = 190.6 g

(b) no. of mole of Mg^{2+} = 2
mass of Mg^{2+} = 2 x 24.3 = 48.6 g

(c) no. of mole of Cl^- = 2 x 2 = 4
mass of Cl^- = 4 x 35.5 = 142 g

7. (a) no. of formula units = 4.5 x 6 x 10^{23} = 2.7 x 10^{24}

(b) One formula unit of K_2SO_4 contains 2 K^+ ions and 1 SO_4^{2-} ion
no. of ions = 2.7 x 10^{24} x (2 + 1) = 8.1 x 10^{24}

8. (a) no. of moles of $CaCl_2$ = 3.3 / (40 + 35.5 x 2) = 0.03
no. of formula units of $CaCl_2$ = 0.03 x 6 x 10^{23} = 1.8 x 10^{22}

(b) no. of chloride ions = 1.8 x 10^{22} x 2 = 3.6 x 10^{22}

9. No. of H_2O molecules in 1 mole = 6 x 10^{23}
Mass of one H_2O molecule = 18 / 6 x 10^{23} = 3 x 10^{-23} g

10. (a) Molar mass of Be = 9 g
1 mole Be atom = 6 x 10^{23} Be atom = 9 g
Mass of 1 Be atom = 9 / 6 x 10^{23} = 1.5 x 10^{-23} g

(b) Mass of 1 SO_2 molecule $= (32 + 2 \times 16) / 6 \times 10^{23}$
$= 1.06 \times 10^{-22}$ g

11.

Substance	Chemical formula	Molar mass of substance ($g\ mol^{-1}$)	Mass of substance present (g)	Number of moles of substance present (mol)	Number of molecules / formula units present
Nitrogen dioxide	NO_2	**46**	**59.8**	1.30	**7.8×10^{23}**
Lead(II) oxide	PbO	**223**	44.6	**0.2**	**1.2×10^{23}**
Ammonium carbonate	$(NH_4)_2CO_3$	**96**	**864**	**9**	5.4×10^{24} formula units

12. ***Remark:*** L is the Avogadro's Number

Substance	Number of mole	Mass (g)	Number of particle
Chlorine molecule (Cl_2)	2	**142**	Cl_2 molecules: **2L** Cl atoms: **4L**
Phosphorus (P_4)	**0.5**	62	P_4 molecules: **L/2** P atoms: **2L**
Sulphur (S_8)	0.5	**128**	S_8 molecules: **L/2** S atoms: **4L**
Sulphur dioxide (SO_2)	**2**	128	SO_2 molecules: **2L** S atoms: **2L** O atoms: **4L**
Sodium hydroxide (NaOH)	**2**	**80**	Total no. of ions: 2.4×10^{24} **= 4L** Na^+ ions: **2L** OH^- ions **2L**
Sulphuric acid (H_2SO_4)	**0.5**	49	H atoms: **L** S atoms: **L/2** O atoms: **2L** H^+ ions: **L** SO_4^{2-} ions: **L/2**
Sucrose ($C_{12}H_{22}O_{11}$)	**0.00833**	**2.85**	C atoms: 6×10^{22} **= 0.1L** H atoms: **(0.1/12) x 22L** O atoms: **(0.1/12) x 11L**
Hydrated copper(II) sulphate ($CuSO_4.5H_2O$)	**0.5**	125	H_2O molecules: **5L/2** Cu^{2+} ions: **L/2** SO_4^{2-} ions: **L/2**
Hydrated sodium carbonate ($Na_2CO_3.10H_2O$)	2	**572**	H_2O molecules: **20L** Na^+ ions: **4L** CO_3^{2-} ions: **2L**

Suggested Answers on Note (Chapter 10) P.11 – 14

1. no. of moles of CO_2 = 12 / 24 = 0.5
   mass of CO_2 = 0.5 x (12 + 16 x 2) = 22.0 g

2. no. of moles of NH_3 = 6 / 24 = 0.25
   no. of NH_3 molecules = 0.25 x 6 x 10^{23} = 1.5 x 10^{23}

3. no. of moles of Cl_2 = 4.56 / 24 = 0.19

4. no. of moles of O_2 = 6 / 24 = 0.25
   no. of O_2 molecules = 0.25 x 6 x 10^{23} = 1.5 x 10^{23}
   no. of O atoms = 2 x 1.5 x 10^{23} = 3 x 10^{23}

5. no. of moles of N_2 = 4.2 / 28 = 0.15
   volume of N_2 = 0.15 x 24 = 3.6 dm^3

6.

Gas	Mass of 1 mole of gas	Mass of gas present	Number of moles of gas	Volume of gas at r.t.p.
H_2	2.0 g	0.40 g	0.20 mol	4.8 dm^3
CO_2	**44.0 g**	4.0 g	**0.091**	**2.18 dm^3**
SO_2	**64.0 g**	**16.0 g**	**0.25**	6000 cm^3
O_2	**32.0 g**	**39.68 g**	1.24 mol	**29.76 dm^3**

7. no. of mole of CH_4 = 1 / 24 = 0.0417
   no. of molecules = 0.0417 x 6 x 10^{23} = 2.5 x 10^{22}

8.

Gas	Molar mass (g mol^{-1})	Mass of gas (g)	No. of moles of gas	No. of gas molecules	Volume of gas at r.t.p. (dm^3)
H_2	**2.0**	1.0	**0.5**	**3 x 10^{23}**	**12.0**
O_2	**32.0**	**12.8**	0.4	**2.4 x 10^{23}**	**9.6**
CO_2	**44.0**	**22.0**	**0.5**	3 x 10^{23}	**12.0**
CH_4	**16.0**	**2.0**	**0.125**	**7.5 x 10^{22}**	3.0
SO_3	**80.0**	**20.0**	0.25	**1.5 x 10^{23}**	**6.0**
Unknown X	**17.0**	4.25	**0.25**	**1.5 x 10^{23}**	6.0

9. Number of moles of methane gas
= volume of methane gas / molar volume of gas
= $1.0\ dm^3 / 24.0\ dm^3\ mol^{-1}$
= 0.042 mol

Number of methane molecules = number of moles of methane gas x L
= $0.042\ mol \times 6.02 \times 10^{23}\ mol^{-1}$
= 2.5×10^{22}

10. Number of moles of gas
= volume of gas / molar volume of gas
= $600\ cm^3 / 24\ 000\ cm^3\ mol^{-1}$
= 0.0250 mol

Mass of gas = (78.98 – 77.53) g = 1.45 g

Molar mass of gas = 1.45 g / 0.0250 mol = $58.0\ g\ mol^{-1}$

Suggested Answers on Note (Chapter 10) P.16 – 17

1.

Urea

$CO(NH_2)_2$ % N = [28 / (12+16+28+4)] x 100% = 46.67%

Sodium nitrate

$NaNO_3$ % N = [14 / (23+14+48)] x 100% = 16.47%

Aqueous ammonia

NH_3 % N = [14 / (14+3)] x 100% = 82.35%

Ammonium sulphate

$(NH_4)_2SO_4$ % N = [28 / (28+8+32+64)] x 100% = 21.21%

Ammonium phosphate

$(NH_4)_3PO_4$ % N = [42 / (42+12+31+64)] x 100% = 28.19%

2. Complete the following table:

Compound	Formula	Relative atomic mass	Formula mass / Relative molecular mass	% by mass of each element in the compound
Sodium chloride	**NaCl**	**Na = 23.1** **Cl = 35.5**	**58.6**	**% Na = 39.4%** **% Cl = 60.6%**
Water	**H_2O**	**H = 1.0** **O = 16.0**	**18.0**	**% H = 11.1%** **% O = 88.9%**
Zinc hydroxide	**$Zn(OH)_2$**	**Zn = 65.4** **O = 16.0** **H = 1.0**	**99.4**	**% Zn = 65.8%** **% O = 32.2%** **% H = 2.0%**
Sulphuric acid	**H_2SO_4**	**H = 1.0** **S = 32.1** **O = 16.0**	**98.1**	**% H = 2.0%** **% S = 32.7%** **% O = 65.2%**

3. Formula mass of $MgSO_4 \bullet 7H_2O$ = 246.4
% by mass of water in $MgSO_4 \bullet 7H_2O$ = 7 x 18 / 246.4 = 51.1%

4. Formula mass of $CaCl_2 \bullet nH_2O$ = 111.1 + 18n
% by mass of water in $CaCl_2 \bullet nH_2O$ = 18n / (111.1 + 18n) = 49.3%
$\Rightarrow$ n = 6

5. Formula mass of $Na_2CO_3 \bullet xH_2O$ = 106 + 18x
no. of mole of $Na_2CO_3 \bullet xH_2O$ = 14.3 / (106 + 18x)
no. of mole of H_2O = 9 / 18 = 0.5
mole ratio of $Na_2CO_3 \bullet xH_2O$: H_2O = 1 : x
$\therefore$ [14.3 / (106 + 18x)] / 0.5 = 1 / x
$\Rightarrow$ x = 10

Suggested Answers on Note (Chapter 10) P.22

2.

Element	Cu	Cl
Mass of element / g	**47.4**	**52.6**
No. of mole	**47.4 / 63.5 = 0.75**	**52.6 / 35.5 = 1.48**
Relative no. of mole (Mole ratio)	**1**	**2**

The empirical formula = **$CuCl_2$**
If the formula mass is 270, then the formula is **Cu_2Cl_4**
If the formula mass is 540, then the formula is **Cu_4Cl_8**

Suggested Answers on Note (Chapter 10) P.23 – 27

1.

Element	Mg	C	O
Mass of element / g	**28.6**	**14.3**	**57.1**
No. of mole	**1.2**	**1.2**	**3.6**
Relative no. of mole	**1**	**1**	**3**

The empirical formula = **$MgCO_3$**

2.

Element	Pb	O
Mass of element / g	**1.374 – 0.126 = 1.248**	**0.126**
No. of mole	**0.006**	**0.0079**
Relative no. of mole	**3**	**4**

The empirical formula = **Pb_3O_4**

3. % by mass of O in compound X = 100 – 40 – 6.7 = 53.3%

Element	C	H	O
Mass of element / g	**40**	**6.6**	**53.3**
No. of mole	**3.33**	**6.7**	**3.33**
Relative no. of mole	**1**	**2**	**1**

∴ The empirical formula = CH_2O.

Let the molecular formula of compound X be $(CH_2O)_n$, where n is a positive integer.

Molar mass of $(CH_2O)_n$ = 60.0 g mol^{-1}

$(12 + 1 \times 2 + 16) \times n = 60$

⇒ n = 2

∴ The molecular formula of compound X = $(CH_2O)_2$

= $C_2H_4O_2$

4. In 100 g

Element	C	H
Mass of element / g	**85.7**	**14.3**
No. of mole	**7.14**	**14.3**
Relative no. of mole	**1**	**2**

∴ The empirical formula = CH_2.

Let the molecular formula of compound Y be $(CH_2)_n$, where n is a positive integer.

Molar mass of $(CH_2)_n$ = 56.0 g mol^{-1}

$(12 + 1 \times 2) \times n = 56$

⇒ n = 4

∴ The molecular formula of compound Y = $(CH_2)_4$

= C_4H_8

5. In 100 g

Element	C	H	O
Mass of element / g	**60.0**	**4.50**	**35.50**
No. of mole	**5**	**4.5**	**2.22**
Relative no. of mole	**9**	**8**	**4**

∴ The empirical formula = $C_9H_8O_4$.

6. In 100 g

Element	C	H	O
Mass of element / g	**26.09**	**4.35**	**69.56**
No. of mole	**2.17**	**4.35**	**4.34**
Relative no. of mole	**1**	**2**	**2**

The empirical formula = CH_2O_2

Let the molecular formula be $(CH_2O)_n$

Therefore, $n (12 + 1 \times 2 + 16 \times 2) = 46 \Rightarrow n = 1$

The molecular formula = CH_2O_2

7. (a)

Element	Pb	O
Mass of element / g	**62.1**	**68.5 – 62.1 = 6.4**
No. of mole	**0.3**	**0.4**
Relative no. of mole	**3**	**4**

The empirical formula = $\mathbf{Pb_3O_4}$

(b) $2PbO + PbO_2 = Pb_3O_4$

$PbO : PbO_2 = 2 : 1$

8. In 100 g

Element	H	S	O
Mass of element / g	**2.40**	**39.0**	**58.60**
No. of mole	**2.40**	**1.22**	**3.66**
Relative no. of mole	**2**	**1**	**3**

The empirical formula = H_2SO_3

9. (a) (i) mass of H = 9 x (2/18) = **1g**

(ii) mass of C = 5.8 – 1 = **4.8g**

(iii)

Element	C	H
Mass of element	**4.8**	**1**
No. of mole	**0.4**	**1**
Relative no. of mole	**2**	**5**

The empirical formula = $\mathbf{C_2H_5}$

(b) (i) 1.2/M = 0.5/24 $\Rightarrow$ **M = 57.6** (molecular mass)

(ii) Let the molecular formula = $(C_2H_5)_n$

n (24+5) = 57.6 $\Rightarrow$ **n ~ 2**

Molecular formula = $\mathbf{C_4H_{10}}$

Suggested Answers on Note (Chapter 10) P.29

Example 1:

$2H_2(g)$	+	$O_2(g)$	$\longrightarrow$	$2H_2O(g)$
2 moles		***1 mole***		***2 moles***
0.5 moles		**0.25** moles		0.5 moles
4 moles		2 moles		**4** moles
1 volume		**0.5** volume		**1** volume
0,5 L molecules		**0.25 L** molecule		**0.5 L** molecules
40 cm^3		**20** cm^3		**40** cm^3

Example 2:

$Cu_2O(s)$	+	$H_2(g)$	$\longrightarrow$	$2Cu(s)$	+	$H_2O(l)$
1 mole		***1 mole***		***2 moles***		***1 mole***
0.25 moles		**0.25** moles		0.5 moles		**0.25** moles
2 moles		2 moles		**4** moles		**2** moles
x volume		1 volume		**x** volume		**x** volume
0 molecule		2L molecules		**0** molecule		**2L** molecule
x cm^3		30 cm^3		**x** cm^3		**x** cm^3

x = very small

Suggested Answers on Note (Chapter 10) P.34 – 42

1. $Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$
   Number of mole of calcium provided = 2.1 / 40 = 0.0525
   According to the equation, 1 mole of Ca reacts with 2 moles of H_2O.
   Number of mole of H_2O needed = 0.0525 x 2 = 0.105
   Mass of H_2O needed = 0.105 x 18 = **1.89 g**

2. Number of moles of Fe_2O_3 = 63.8 / 159.6 = 0.4
   Number of moles of Al required = 2 x 0.4 = 0.8
   Mass of Al required = 0.8 x 27 = **21.6 g**

3. Number of mole of S = 5.5
   Number of mole of SO_2 = 5.5
   Mass of SO_2 formed = 5.5 x (32 + 16 x 2) = **352 g**
   Volume of SO_2 formed in r.t.p. = 5.5 x 24 = **132 dm^3**

4. Number of mole of Pb = 74.6 / 207 = 0.36
   Number of mole of Pb_3O_4 required = 0.36 / 3 = 0.12
   Mass of Pb_3O_4 = 0.12 x 685 = **82.3 g**

5. $2CuO(s) + C(s) \longrightarrow 2Cu(s) + CO_2(g)$
   Number of mole of CuO = 15 / 79.5 = 0.189
   Number of mole of C provided = 1.5 / 12 = 0.125
   According to the equation, 2 moles of CuO react with 1 mole of C.
   ∴ 0.125 mole of C needs 0.25 mole of CuO for complete reaction.
   However, there is only 0.189 mole of CuO provided.
   ∴ CuO is the limiting reactant or limiting reagent (or C is in excess).
   Number of moles of Cu formed = 0.189
   Mass of Cu = 0.189 x 63.5 = **12 g**
   Number of moles of CO_2 = ½ x 0.189 = 0.0945
   Volume of CO_2 formed = 0.0945 x 24 = **2.268 dm^3**

6. $Mg(s) + 2HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$
   Number of mole of Mg = 0.144
   Number of mole of $MgCl_2$ = 0.144
   Mass of $MgCl_2$ formed = 0.144 x (24.3 + 35.5 x 2) = **13.72 g**
   Number of mole of $H_2(g)$ = 0.144
   Volume of H_2 formed = 0.144 x 22.4 = **3.23 dm^3**

7. $2Al_2O_3(l) \longrightarrow 4Al(l) + 3O_2(g)$
   Number of mole of Al = 5.4 / 27 = 0.2
   Number of mole of Al_2O_3 reacted = 0.2 / 4 x 2 = 0.1
   Mass of Al_2O_3 reacted = 0.1 x (27 x 2 + 16 x 3) = **10.2 g**
   Number of mole of O_2 formed = 0.2 / 4 x 3 = 0.15
   Volume of O_2 formed = 0.15 x 24 = **3.6 dm^3**

8. Number of mole of sodium carbonate = 5.3 / 106 = 0.05
Number of mole of HCl = 2 x 0.04 = 0.08
Sodium carbonate is in excess!!!
Number of mole of carbon dioxide = 0.08 / 2 = 0.04
Volume of carbon dioxide = 0.04 x 24 = **0.96 dm^3**

9. Number of mole of copper(II) oxide = 15.9 / 79.5 = 0.2
Number of mole of hydrogen = 0.2
Mass of copper = 0.2 x 63.5 = **12.7 g**

10. Number of mole of sulphuric acid = 3 x 0.025 = 0.075
Number of mole of hydrated copper(II) sulphate = 0.075
Molar mass of hydrated copper(II) sulphate = 249.5 g
Mass of hydrated copper(II) sulphate = 0.075 x 249.5 = **18.1725 g**

11. $NH_4Cl + NaOH \longrightarrow NH_3 + NaCl + H_2O$
$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$
Number of mole of ammonium sulphate = 2.64 / 132 = 0.02
Number of mole of ammonia = 0.02 x 2 = 0.04
Number of mole of ammonium chloride = 0.04
Mass of ammonium chloride = 0.04 x 53.5 = **2.14 g**

12. $CaCO_3(s) + 2HCl(g) \longrightarrow CaCl_2(aq) + H_2O(g) + CO_2(g)$
Number of mole of CO_2 = 1.43 / 44 = 0.0325
Number of mole of $CaCO_3$ = 0.0325
Mass of pure $CaCO_3$ = 0.0325 x 100 = 3.25 g
% by mass of $CaCO_3$ in the sample = 3.25 / 3.8 x 100% = **85.5%**

13. Number of mole of N_2 = 84 / 28 = 3
Number of mole of NaN_3 = 3 / 3 x 2 = 2
Mass of NaN_3 = 2 x (23 + 14 x 3) = **130 g**

14. (a) Number of mole of LiOH = 50 / (7 + 16 + 1) = 2.08
Number of mole of CO_2 absorbed = 2.08 / 2 = 1.04
Mass of CO_2 absorbed = 1.04 x 44 = **45.83 g**

(b) Number of mole of CO_2 = 100 / 44 = 2.27
Number of mole of Li_2CO_3 = 2.27
Mass of Li_2CO_3 = 2.27 x (7 x 2 + 12 + 16 x 3) = **167.98 g**

15. (a) $2Ag_2O(s) \longrightarrow 4Ag(s) + O_2(g)$

(b) Number of mole of Ag = 6.52 / 108 = 0.06
Number of mole of Ag_2O = 0.06 / 4 x 2 = 0.03
Mass of Ag_2O = 0.03 x (108 x 2 + 16) = 6.96g
% by mass of Ag_2O = 6.96 / 8 x 100% = **87%**

16. $Hg(l) + Br_2(l) \longrightarrow HgBr_2(s)$
Number of moles of Hg present = 21.5 / 200.6 = 0.107 mol
Number of moles of Br_2 present = 15.6 / 159.8 = 0.0976 mol
According to the equation, 1 mole of Hg reacts with 1 mole of Br_2 to produce 1 mole of $HgBr_2$. During the reaction, 0.0976 mole of Br_2 reacted with 0.0976 mole of Hg. Therefore Hg was in excess. The amount of Br_2 limited the amount of $HgBr_2$ produced.
Number of moles of $HgBr_2$ produced = 0.0976 mol
Molar mass of $HgBr_2$ = 200.6 + 2 x 79.9 = 360.4 g mol^{-1}

(a) Mass of $HgBr_2$ produced = 0.0976 x 360.4 = **35.2 g**
(b) Mass of Hg reacted = 0.0976 x 200.6 = 19.6 g
Mass of Hg left = (21.5 – 19.6) g = **1.9 g**

17. (a) Number of mole of $TiCl_4$ present = 4.75 x 10^7 / 190 = 2.5 x 10^5
Number of mole of Mg present = 1.46 x 10^7 / 24.3 = 6.01 x 10^5
∴ Mg was in excess.
Theoretically, number of mole of Ti produced = 2.5 x 10^5
Theoretical yield of Ti = 2.5 x 10^5 x 48 = **1.2 x 10^7 g**

(b) % yield = 1.06 x 10^7 / 1.2 x 10^7 x 100% = **88.3%**

18. (a) Number of mole of Li present = 8.28 / 7 = 1.18
Number of mole of N_2 present = 10.6 / 28 = 0.37
∴ N_2 was in excess.
Theoretically, number of mole of Li_3N produced = 1.18 / 6 x 2 = 0.39
Theoretical yield of Li_3N = 0.39 x (7 x 3 + 14) = **13.65 g**

(b) % yield = 3.97 / 13.65 x 100% = **29.08%**

Suggested Answers on Note (Chapter 10) P.44 – 47

1. Molar mass of MnO_2 = 54.9 + 2 x 16.0 = 86.9 g mol^{-1}
   Mass of MnO_2 in the nodule = 0.0400 x 86.9 = 3.48 g
   Percentage by mass of MnO_2 in the nodule = (3.48 / 15.0) x 100% = 23.2%

2. (a) To prevent the condensed water from running back to the tube and crack the hot glass.

   (b) Test the liquid with dry cobalt(II) chloride paper.
   The liquid turns the paper from blue to pink.

   (c) To prevent 'sucking back' of the liquid.

   (d) Formula mass of $FeSO_4 \bullet xH_2O$
   = (55.8 + 32.1 + 4 x 16.0) + x(2 x 1.0 + 16.0)
   = 151.9 + 18x

   1 mole of $FeSO_4 \bullet xH_2O$ contains x moles of H_2O.
   i.e. (151.9 + 18x) g of $FeSO_4 \bullet xH_2O$ contain 18x g of H_2O.

   30.6 g of $FeSO_4 \bullet xH_2O$ contain 13.9 g of H_2O.

   18x / (151.9 + 18x) = 13.9 / 30.6 $\Rightarrow$ x = 7

3. (a) Suppose we have 100 g of glucose, so there are 40.0 g of carbon, 6.60 g of hydrogen and 53.4 g of oxygen.

	Carbon	**Hydrogen**	**Oxygen**
Mass of element in the compound	40.0 g	6.60 g	53.4 g
Relative atomic mass	12.0	1.0	16.0
Number of moles of atoms that combine	40.0 / 12.0 = 3.33 mol	6.60 / 1.0 = 6.60 mol	53.4 / 16.0 = 3.33 mol
Mole ratio of atoms	3.33 / 3.33 = 1	6.60 / 3.33 = 2	3.33 / 3.33 = 1

   $\therefore$ the empirical formula of glucose is CH_2O.

   (b) Let $(CH_2O)_n$ be the molecular formula of glucose.
   Relative molecular mass of glucose = n(12.0 + 2 x 1.0 + 16.0) = 30n
   $\therefore$ 30n = 180 $\Rightarrow$ n = 6
   $\therefore$ the molecular formula of glucose is $(CH_2O)_6$ or $C_6H_{12}O_6$.

4. (a) Method 1

$2Fe(OH)_3(s) \longrightarrow Fe_2O_3(s) + 3H_2O(g)$

Molar mass of $Fe(OH)_3$ = 55.8 + 3 x (16.0 + 1.0) = 106.8 g mol^{-1}
Number of moles of $Fe(OH)_3$ = 5.35 / 106.8 = 0.0501 mol

According to the equation, 2 moles of $Fe(OH)_3$ give 3 moles of H_2O upon heating.
∴ number of H_2O formed = 3/2 x 0.0501 = 0.0752 mol

Molar mass of H_2O = 2 x 1.0 + 16.0 = 18.0 g mol^{-1}

Mass of H_2O formed = 0.0752 x 18.0 = 1.35 g

Method 2

$2Fe(OH)_3(s) \longrightarrow Fe_2O_3(s) + 3H_2O(g)$

Molar mass of $Fe(OH)_3$ = 55.8 + 3 x (16.0 + 1.0) = 106.8 g mol^{-1}

Molar mass of H_2O = 2 x 1.0 + 16.0 = 18.0 g mol^{-1}
According to the equation, 2 moles of $Fe(OH)_3$ give 3 moles of H_2O upon heating.
∴ 2 x 106.8 g of $Fe(OH)_3$ give 3 x 18.0 g of H_2O upon heating.

Mass of H_2O formed = 5.35 x (3 x 18.0)/(2 x 106.8) = 1.35 g

(b) Suppose we have 100 g of the oxide, so there are 72.4 g of iron and 27.6 g of oxygen.

	Iron	**Oxygen**
Mass of element in the oxide	72.4 g	27.6 g
Relative atomic mass	55.8	16.0
Number of moles of atoms that combine	72.4 / 55.8 = 1.30 mol	27.6 / 16.0 = 1.73 mol
Mole ratio of atoms	1.30 / 1.30 = 1.00	1.73 / 1.30 = 1.33
Simplest whole number ratio of atoms	1 x 3 = 3	1.33 x 3 = 4

∴ the empirical formula of the oxide is Fe_3O_4.

5. (a) $2ZnS(s) + 3O_2(g) \longrightarrow 2ZnO(s) + 2SO_2(g)$
$2ZnO(s) + C(s) \longrightarrow 2Zn(s) + CO_2(g)$

(b) Molar mass of ZnO = 65.4 + 16.0 = 81.4 g mol^{-1}
Number of moles of ZnO = 48.8 / 81.4 = 0.600 mol

According to the equation, 2 moles of ZnO require 1 mole of C for reduction to give 2 moles of Zn.

$\therefore$ number of moles of Zn obtained = 0.600 mol
number of moles of C required = 0.600 / 2 = 0.300 mol

(i) Mass of Zn obtained = 0.600 x 65.4 = 39.2 g

(ii) Mass of C required = 0.300 x 12.0 = 3.60 g

6. (a) $2Al(s) + 3CuSO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3Cu(s)$

(b) Number of moles of Al reacted = 1.61 / 27.0 = 0.0596 mol
According to the equation, 2 moles of Al react to give 3 moles of Cu.
$\therefore$ number of moles of Cu produced = 3 / 2 x 0.0596 = 0.0894 mol

Theoretical yield of Cu = 0.0894 x 63.5 = 5.68 g

Percentage yield of Cu = (2.58 / 5.68) x 100% = 45.4%

7. $4KO_2(s) + 2H_2O(g) + 4CO_2(g) \longrightarrow 4KHCO_3(s) + 3O_2(g)$
Molar mass of CO_2 = 12.0 + 2 x 16.0 = 44.0 g mol^{-1}
Number of moles of CO_2 exhaled = 14.0 / 44.0 = 0.318 mol

According to the equation, 4 moles of CO_2 require 4 moles of KO_2 for complete reaction.

$\therefore$ number of moles of KO_2 required = 0.318 mol

(a) Molar mass of KO_2 = 39.1 + 2 x 16.0 = 71.1 g mol^{-1}

Theoretical mass of KO_2 required = 0.318 x 71.1 = 22.6 g

(b) Since the process is only 80% efficient, the mass of KO_2 required
= 22.6 / 80% = 28.3 g

8. $MnO_2(s) + 4HCl(aq) \longrightarrow MnCl_2(aq) + Cl_2(g) + 2H_2O(l)$

Molar mass of MnO_2 = 54.9 + 2 x 16.0 = 86.9 g mol^{-1}

Number of moles of MnO_2 present = 217 / 86.9 = 2.50 mol

Molar mass of HCl = 1.0 + 35.5 = 36.5 g mol^{-1}

Number of moles of HCl present = 274 / 36.5 = 7.51 mol

(a) According to the equation, 1 mole of MnO_2 reacts with 4 moles of HCl to produce 1 mole of Cl_2. In this case, the mole ratio of MnO_2 to HCl was 1:3. Therefore all the HCl would be used up. The limiting reagent was HCl.

(b) Number of moles of Cl_2 produced = 7.51 / 4 = 1.88 mol

Molar mass of Cl_2 = 2 x 35.5 = 71.0 g mol^{-1}

Mass of Cl_2 produced = 1.88 x 71.0 = 133 g

(c) Number of moles of MnO_2 used = 7.51 / 4 = 1.88 mol

Mass of MnO_2 used = 1.88 x 86.9 = 163 g

Mass of MnO_2 (excess reagent) left = (217 – 163) g = 54 g