Gas laws

1. ***X: t_1= 28.3sec*** ***RMM = ?***
Q_2: t_2= 20.0sec ***RMM=32***

$T \propto \sqrt{MM}$ ✓

$$\frac{T_1}{T_2} = \sqrt{\frac{X}{32}}$$

$$\left(\frac{T_1}{T_2}\right)^2 = \frac{X}{32}$$ ✓

$$\left(\frac{28.3}{T_2}\right)^2 = \frac{X}{32}$$ ✓

$$X = \frac{28.3^2 \times 32}{400}$$ ✓

$X = 64$ ✓

2. ***(a) The rate of diffusion of a gas is inversely proportional to the square root of its density under the same conditions of temperature and pressure***

(b) Rate of gas V=$\frac{1}{5}$ x $\frac{100cm}{10sec}$

= 2cm/sec ✓ ½

Rate of W = $\frac{10cm}{10sec}$

= 1cm/sec ✓ ½

$$\frac{RV}{RW} = \sqrt{\frac{MW}{MV}} \qquad = \frac{2}{1} = \sqrt{\frac{MW}{16}}$$

$$\left(\frac{2}{1}\right)^2 = \frac{MW}{16}$$

$$\frac{4}{1} = \frac{MW}{16}; = \frac{4}{1} \times 16$$

MW = 64

3. ***(a) The volume of a fixed mass of a gas is directly proportional to its absolute temperature at constant Pressure*** ✓

(b) Apply combined gas law; $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$V_1 = 3.5 \times 10^{-2}\ m^3$ $V_2 = 2.8 \times 10^{-2} m^3$
$P_1 = 1.0 \times 10^5 Pa$ P_2= 1.0 x 105Pa ✓ ½
T_1 = 291K T_2= ?

$$T_2 = \frac{P_2V_2T_1}{P_1V_1}$$

$$T_2 = \frac{1.0 \times 10^5 Pa \times 2.8 \times 10^{-2} m^3 \times 291K}{1.0 \times 10^5 Pa \times 3.5 \times 10^{-2} m^3}$$

T_2 = 232.8k ✓

4. ***TsO_2 = $\sqrt{R.M.N.SO_2}$*** ✓½

TO_2 R.M.MO_2

SO_2 = 32 + (16 x 2) = 64 ✓½

O_2 = (16 x 2) = 32 ✓½

$\frac{TsO_2}{50} = \frac{64}{32}$ ✓½ = 70.75 ✓½

5. a) The rate of diffusion of a fixed mass of a gas is inversely proportional to the square root of it density at constant temperature and pressure

b) RHCl = $\frac{30\ cm^3}{20\ se}$ = 1.5 cm^3 see

$\frac{RHCL}{RSO_2} = \frac{\sqrt{MSO_2}}{\sqrt{MHCL}}$

$\frac{(1.5)^2}{RSO_2} = \frac{\sqrt{64}}{\sqrt{36.5}}$

$(RSO_2)^2 = \frac{2.25 \times 36.5}{64}$

$RSO_2 = \sqrt{\frac{2.25 \times 36.5}{64}}$

1.133 cm/ sec

1.133 cm^3 ______________ 1 sec

42 cm^3 = $\frac{42 \times 1}{1.133}$

= 37 sec

6. a) Boyles' law For a fixed mass of a gas, volume is inversely promotional to pressure at constant temperature

b)

c) $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ √ ½ $V_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2}$ √ ½

$\frac{250 \times 273 - 23}{273 + 127}$ √ ½

= 156.5cm^3

7. a) RFM of $CaCO_3$ = 40 + 12 + 48

= 100kg. √½

∴ 100 kg of $CaCO_3$ ≡ 22.4dm^3 of $CO_2(g)$

1000 kg " " ?

= $\frac{22.4 \times 1000}{100}$ √1 = 224 dm^3 √½

8. T_1 = 23+273 =296 T_2 = -25+273 = 248

V_1 = 200cm^3 V_2 = ?

P_1 = 740mmHg P_2 = 780mmHg

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$\frac{740x200}{296}$ √1 = $\frac{780x?}{248}$ √1

$\therefore x = \frac{740 \times 200 \times 248}{296 \times 780}$

= 158.974 cm^3√1 (penalize ½ mark for units)

9. $\frac{Rk}{Rs} = \sqrt{\frac{Ms}{Mk}}$

$\therefore \frac{12}{7.2} = \sqrt{\frac{x}{16}}$ √½

$X = \frac{12^2}{7.2^2} \times 16$ √½

= 44.464√

10. (a) When gases combine they do so in volume which bear a simple ratio to one another and to the product if gaseous under standard temperature and pressure √1

11. a) Rate of diffusion is whereby proportional to molecular mass of a gas. √1

b) $\frac{TCO_2}{TCO} = \frac{MCO_2}{MCO}$ √½

$\Rightarrow \frac{200}{T} = \frac{44}{28} = \frac{44}{28}\frac{11}{7}$ √½

$\Rightarrow \left(\frac{200}{T}\right)^2 = \frac{11}{7}$

$\Rightarrow \frac{T}{200} = \frac{7}{11}$

$\Rightarrow$ T = 200.0.79772√½ = 159.5 Seconds. √½

12. a) Y √1

b) Z and W √1 have same atomic number but different mass number. √1

13. (a) Gas P

(b) $\frac{RQ}{RP} = \frac{RMMP}{RMMQ}$

$\frac{18}{54} = \frac{x}{17}$ 2

$\frac{1^2}{3^2} = \frac{x}{17}$

$\frac{1}{9} = \frac{x}{17}$

9x = 17

x = $^{17}/_9$

x = 1.88

Q = It

= 5 x 386 = 1930C

(b) $Pb^{2+}_{(l)}$ + 2e $Pb_{(s)}$ (½mk)

If 2 x 96500C = 207 (½ mk)

1930C = $\frac{1930 \times 207}{2 \times 96500}$ (½ mk)

= $\frac{399510}{193000C}$ (½mk)

= 2.07g (½mk)

14. ***i) Delocalized electrons***

ii) Mobile ions

iii) Mobile ions

15. $\frac{TNH_3}{TB} \quad \frac{MNH_3}{MB}$ √ ½

$\frac{TNH_3}{TB} = \frac{17}{34}$

$\frac{TNH_3}{110} = \frac{17}{34}$ √ ½

TNH3 = 110 X $\frac{17}{34}$ √ ½ = 77.78 seconds √ ½

16. $\frac{P_1 V_1}{T1} = \frac{P_2 V_2}{T_2}$

$\frac{1x5}{246} = \frac{2 \, xV_2}{400}$

$V2 = \frac{400 \, x1 \, x \, 5}{2 \, x246}$

$= 4.065 \, dm^3$

17. ***a)*** $V_1 = 200 \, cm^3$ $V_2 = ?$

$T_1 = 296 \, K$ $T_2 = 284K$

$P_1 = 740 \, mmHg$ $P_2 = 780 \, mm \, Hg$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{740 \, mm \, Hg \, x \, 200cm^3 \, x \, 248K}{296K \, x \, 780 \, mm \, Hg}$

$= 158.97 \, cm^3$

b) 60 l ✓1

18. ***a) Grahams law states***

Under the same conditions of pressure and temperature, the rate of diffusion of a gas is inversely proportional to the square root of its density

b) $\frac{Time \, CO_2}{Time \, NO_2} = \frac{\sqrt{M_rCO_2}}{M_rNO_2}$

Where 100cm³ of CO₂ takes 30 seconds

$\therefore$ ***150cm3 of CO₂ takes*** $^{30}/_{100} \, x \, 150$

= 45 seconds√

$\frac{45^2}{TNO_2} = 0.975$

$\frac{45}{TNO_2} = \sqrt{\frac{44}{46}}$ ____ $TNO_2 = \frac{45}{0.978}$

$TNO_2 = 46 \, sec$

OR

$\frac{RCO_2}{} = \sqrt{M_rNO_2}$

RNO_2 M_rCO_2

But $RCO_2 = \frac{100cm^3}{30\ s} = 3.33\ cm^3$ per sec

$$\frac{3.33}{RNO_2} = \sqrt{\frac{46}{44}}$$

$$= 1.0225$$

$$RNO_2 = \frac{3.33}{1.0225}$$

= 3.26 cm^3 per second

Time for No = $\frac{150\ cm^3}{3.26cm\ sec^{-1}}$ = 46 secs

1. ***When a magnesium ribbon is heated in air it combines with oxygen forming magnesium oxide. When potassium manganate (VII) is heated it decomposes giving off oxygen which escapes in air***

2. ***RFM of NaOH = 40***
   Moles of NaOH = $\frac{8}{40}$ = 0.2M ✓
   Moles of NaOH in 25cm3
   $\frac{25 \times 0.2}{1000} = 0.005$ ✓
   Mole ratio 1:2
   Moles of acid = $\frac{0.005}{2}$
   = 0.0025
   $\frac{1 \times 0.245}{0.0025} = 98$ ✓

3. ***No. Of moles of HNO_3 acid***
   $\frac{50 \times 2}{1000} = 0.1$moles
   Mole ratio 1:1 ✓
   The KOH will have 0.1moles; $\frac{0.1 \times 100}{50} = 0.2$moles
   Then D grams is 0.2 X 56
   = 11.2g

4. ***Number of moles of Q = $\frac{960cm^3 \times 1mole}{24000cm^3}$***
   = 0.04moles
   Equation:
   $Na_2SO_{3(s)} + 2HCL_{(aq)} \qquad 2NaCl_{(aq)} + SO_{2(g)} + H_2O_{(l)}$
   Mole ratio $Na_2SO_3 : SO_2$ is 1:1
   ∴No. of moles of Na_2SO_3 = 0.04moles
   Mass of Na_2SO_3 = 126$gmol^{-1}$ x 0.04
   = 5.04g

5. ***From the equation***
   - (3x24) litres of chlorine react with iron to produce [(56 x 2) + (35.5 X3)] g of $Fecl_3$.

325 g of $Fecl_3$ is produced by 72 litres of cl_2
Then 0.5g of fecl3 is produced by:

$$\frac{0.5 \times 72}{325} = 0.11078 \text{ litres}$$

$$= 110.78 \text{ cm}^3$$

6. *RMM (CH_3OOH) = 60*
Mass of $15cm^3$ and = 1.05 x 15 = 15.75g ✓ ½ ✓ ½
Moles in $500cm^3$ solution = $\frac{15.75}{60}$ = 0.2625 ✓ 1

$$Molarity = \frac{1000 \times 0.2625}{5000} = 0.525M$$ ✓ ½

7. *If $24000cm^3$ = 1mole*
$150cm^3$ = ? ✓

$$\frac{150 \times 1}{24000} = 0.00625 \text{moles of } CO_2$$

Since the ratio of Na_2CO_3; O_2 produced is 1:1 the mass of Na_2CO_3 = 0.00625 x 106 = 0.6625g

Na_2Co3	H_2O
Mass 0.6625g RFM 106 Mole 0.6625 = $\frac{0.00625}{106}$ Ratio $\frac{0.00625}{0.00625}$ = 1 $Na_2CO_3.9H_2O$	1.0125g 18 $\frac{1.0125}{0.5625}$ = 18 $\frac{0.05625}{0.0.00625}$ = 9

8. *$MgCl_2$ $Mg^{2+}_{(s)}$ $2Cl^-$*

R.F.M of $MgCl_2$ = 24 + 71
= 95
Moles of Mass = $\frac{1.7}{95}$
R.F.M
= 0.01789moles
I mole of $MgCl_2$ = 2moles of Cl-ions
0.01789moles of $MgCl_2$ = 0.01789 x 2
= 0.03478moles of Cl^-ions
1mole = 6.0×10^{23}ions
0.03578moles = $\frac{0.03578 \times 6.0 \times 10^{23}}{1}$
= 2.1468×10^{22} ions of Cl^-

12. *Mass of O_2 = (4.0 – 2.4)= 1.6g*
Moles of O_2 = $^{1.6}/_{16}$ = 0.1

If 1 mol O_2 ________ $24000cm^3$
0.1 Mol Mg = 0.5 mol $_{O2}$ = $1200cm^3$

OR

2mg	:	O2
2(24)		24000

$^{2.4}/_{2(24)} \quad = {}^{x}/_{240000}$

$X = \underline{2.4 \times 24000} \quad = 1200cm3$
$\quad\quad 2(2.4)$

13. i) Fe S O H_2O

$^{20.2}/_{56}$ $^{11.5}/_{32}$ $^{23.0}/_{16}$ $^{45.3}/_{18}$

$^{0.36}/_{0.36}$ $^{0.36}/_{0.36}$ $^{1.44}/_{0.36}$ $^{2.52}/_{0.36}$

1 1 4 7

Empirical formula: $FeSO_4 + H_2O$

ii) 6.95g $= {}^{6.95}/_{278} = 0.025$

$\therefore$ 0.05 moles in $250cm^3 = 0.025 \times {}^{1000}/_{250} = 0.1$

14. R.F.M of $pbI_2 = 207 + (127X2) = 461$

2 moles of I^- ions produces I mole of pbI_2

Moles of I^- ions = $\frac{0.1 X 300}{1000}$ = 0.03 mole

Mole ratio PbI_2: I^- I : 2 mole of PbI2 formed = $\frac{0.03}{2}$ = 0.05

Mass of pbI_2 formed = 0.015 mole X 461

= 6.915 g

d(i) Yellow precipitate

15. a) i)

ii) At 25C, sodium chloride is in solid form. Ions cannot move. Between 801 and 1413C sodium chloride is in liquid state, ions are mobile

b) Both ammonia and water are polar moleculer and hydrogen bonds are formed

c) N _________ H // co-ordinate bond / Dative bond

d) i) Allotrope

ii) Add methylbenzene to soot in a beaker. Shake and filter. Warm the filtrate to concentrate it. Allow the concentrate to cool for crystals to form. Filter to obtain crystals of fullerene

iii) $^{720}/_{12}$ = 60

16. Mass of O_2 = (4.0 – 2.4)= 1.6g

Moles of O_2 = $^{1.6}/_{16}$ = 0.1

If 1 mol O_2 ________ 24000cm3

0.1 Mol Mg = 0.5 mol O2 = 1200cm3

OR

2mg	*:*	*O_2*
2(24)		*24000*
$^{2.4}/_{2(24)}$	*$=^{x}/_{240000}$*	

X = $\frac{2.4 x 24000}{2(2.4)}$ = 1200cm3

17. i) C_nH_{2n}, where n = No. of carbon atoms

ii) 70

iii) C_5H_{10}, $CH_3CH{=}CHCH_2CH_3$

OR $CH_3CH_2CHCH_2{=} CH_2$

18. i)

Fe	*S*	*O*	*H_2O*
$^{20.2}/_{56}$	*$^{11.5}/_{32}$*	*$^{23.0}/_{16}$*	*$^{45.3}/_{18}$*
$^{0.36}/_{0.36}$	*$^{0.36}/_{0.36}$*	*$^{1.44}/_{0.36}$*	*$^{2.52}/_{0.36}$*
1	*1*	*4*	*7*

Empirical formula: $FeSO_4 + H_2O$

ii) 6.95g = $^{6.95}/_{278}$ = 0.025

∴ 0.05 moles in 250cm^3 = 0.025 x $^{1000}/_{250}$ = 0.1

Concentration = $^{6.95}/_{278}$ x $^{1000}/_{250}$ = 0.1

19. a) *Zinc is more reactive// higher reduction potential than copper it will react with// get oxidized in preference to iron oxygen to form Zinc Oxide coat which protects iron from rusting*

ii) Sacrificial protection or cathodic protection

20. *Mole of Mg that reacted = $\frac{\text{Answer in (c) (ii)}}{1000} \times \frac{2}{2}$*

$= \frac{26}{1000} = 0.026$ √½

Mass of Mg in the alloy = 0.026 x 24

= 0.624g √½

Mass Cu in the alloy = (1.0 – 0.624)

= 0.376g √½

% of Cu $= \frac{0.376}{1.0} \times 100$

= 37.6% √½

21. $NH_{(g)} + HNO_{(g)}$ $NH_4NO_{3(s)}$ √1

RMM of $NH_4NO_3 = 80$

Moles of $NH_4NO_3 = \frac{4800}{80} = 60$ *moles* √1

RMM of $NH_3 = 17$

Mass of NH_3 *= 60 x 17 = 1020KJ* 1

22. *From the equation of step 3*

$SO_{3(g)} + H_2SO_{4(L)}$ ____________ $H_2S_2O_{7(L)}$

RFM of H2S2O7 = 2 + (2 X 32) + (7 X 16) = 178 √ ½ mark

178g of Oleum are produced by 22.4 liters of SO_3 *√½ mark*

178 kg " " " " " " $\frac{178 \times 1000 \times 22.4L}{178g}$ *√1 ½ mark*

= 22,4000 liters √½ mark

(Total 13 marks)

23. *i) Moles of copper =* $\frac{0.635}{63.5}$ *= 0.01 moles*

Volume of 1M Nitric acid $\frac{40}{0.01}$ *= 4000cm3 √½ mark*

- Use value in d(ii) above

ii) $\frac{480cm^3}{0.01}$ *√½ mark = 48,000 cm^3 √½ mark*

OR $\underline{4000 \times 480}$ *= 48,000cm3 √½ mark*

40cm³

i.e. $\frac{\text{Answer in e(i)} \times 480cm^3}{\text{Answer in d(i)}}$ **[Total = 11 marks]**

24. *(i)* $\frac{35.2 \times 1000}{100 \times 16}$ ✓ ½

$= 10$ *Moles* ✓ ½

Or mass of $CH_4 = \frac{35.2 \times 5}{1000} = 1.76g$ ✓ ½

Mass in g $= 1.76 \times 1000 = 1760kg$ ✓ ½

Moles of methane $= \frac{1760}{16}$ ✓ ½

$= 110$ *Moles* ✓ ½

(ii) $CH_4 + 2O_2 \quad CO_2 + 2H_2O$ – *(ignore states)*

Volume $= 110 \times 24.0$

$= 2640dm^3$

Mark consequential from equation and b(ii) (Without equation max *TZM*)

25. *Volume of Cl2 used*

$= 0.047 \times 24$ ✓ 1

$= 1.128dm^3$ ✓ ½

26. *Mass due Carbon in* $CO_2 = {}^{12}/_4 \times 35.2$

$= 0.96$

Moles carbon $= {}^{0.96}/_{12} = 0.08$

Mass due Hydrogen in $H_2O = 2/18 \times 1.40$

$= 0.156$

Moles hydrogen $= \frac{0.156}{1} = 0.156$

Mole ratio C:H = 1: 1.95

$E.F = CH_2$

27. $Na_2CO_3 \ x H_2O \qquad Na_2CO_3 + H_2O$ √1

34.8g	$\frac{15.9g}{106}$	$\frac{18.9g}{18}$
	$\frac{0.15}{0.15}$ √1	$\frac{1.15}{0.15}$
	x =	7 √1

3

28. *% of* H_2O *lost = 14.5%^*

5 of anhydrous $Na_2CO_3 = 85.5\%$ *(½mk)*

R.F.M of $Na_2CO_3 = 106$ *(½mk)*

RMM of $H_2O = 18$ *(½mk)*

$NaCO_3$	H_2O	
$\frac{85.5}{106}$	$\frac{14.5}{18}$	*(½mk)*
$\frac{0.8066}{0.8055}$	$\frac{0.8055}{0.8055}$	*(½mk)*

n = 1 ($Na_2CO_3.H_2O$) (½mk)

29. ***Moles of $Na_2CO_3 = \frac{20 \times 0.1}{1000} = 0.002$ moles***

$Na_2CO_3 + H_2SO_{4(aq)}$ ________ $Na_2SO_{4(aq)} + H_2O_{(L)} + CO_{2(g)}$
Mole ratio 1 : 1
Moles of H_2SO_4 = Moles of Na_2CO_3
= 0.002 moles
Molarity of $H_2SO_4 = \frac{10000 \times 0.002}{13} = 0.154$ moles

30.

Element	C	H	O
%	68.9	13.5	21.6
Molar mass	12	1	16
Moles	$^{68.9}/_{12}$ 5.403	$^{13.5}/_{1}$ 13.5	$^{216}/_{16}$ 1.35
MR	$^{5.43}/_{1.33}$ 4	$^{13.5}/_{1.35}$ 10	$^{1.35}/_{1.35}$ 1
Ratio	4	10	1

h ($C_4H_{10}O$) = 74
h (12x4) + (10x1) +16 = 74
74h = 74
H= 1
Formula $C_4H_{10}O$

31. ***Moles $C_4H_{10} = \frac{1.12}{22.4} = 0.05$ mol***
Heat produced + 0.05 X (3000) = 150 kj
Usefull heat = $\frac{75X150}{100}$ = 112.5 kj
Let volume of water = V
Room temperature = 25°C
Boiling point = 100°C
Change in temperature, ΔT = 100-25 = 75°C ½ mk
ΔT X mass X C Q 315V = 112500
= $\frac{75 X V X 4.2}{1000}$ = $\frac{112.5}{1}$ V = $\frac{112500}{315}$ ½ mk
V = 357.km³ ½ mk

32. ***RFM Na_2CO_3 = 43 + 12 + 48 = 106***
Mol. $Na_2CO_3 = \frac{19.6}{106}$ = 0.8149057
Molarity of $Na_2 Co_3 = \frac{0.1849057}{0.25}$ = 0.73962m
$Na_2 Co_{3(aq)}$ + Mg $Cl_{2(aq)}$ + $MgCo_{3(s)}$
Mole ratio Na CO_3 : Mg Cl_2 is 1:1
∴ mol. Mg Cl_2 Reacted = 0.1849

If 2.0 mol. = 1000cm3 solution mg cl_2

= 0.1849mol = $\frac{0.1849 \times 1000}{2}$

= 92.45 or 92.5 cm^3

33. *i)*

ACID	BASE	
1	2	
½ 0.004 = 0.002 moles √ ½	$\frac{20cm^3}{1000cm^3} \times 0.2$ moles	= 0.004 moles

$25cm^3$ ________ 0.002 moles √ ½

$1000cm^3$ ______ ?

$1000cm^3$ X 0.002 moles = 0.08 M√ ½

ii) 0.08 moles ________________ 10.08g $H_2C_2O_4xH_2O$ √ ½

1 mole __________________ ?

$\frac{1 \text{ mole}}{0.08 \text{ moles}} \times 10.08$ = 126 √ ½

126 _______ $H_2C_2O_4xH_2O$

18x = 126 – 90 √ ½

18x = 36

X = 2 √ ½

34. *$Mg_{(g)} + 2HCL_{(aq)}$ ____________ $MgCl_{2\,(aq)} + H_{2\,(g)}$*

24g ____________________________________ $22.4dm^3$

16g ____?

1.6 gx $22.4dm^3$ √ ½ = 1.4933 dm^3

35. *a) $2SO_2(g) + O_2(g)$ $2SO_3(g)$, SO_2 : O_2*

2	1	2	60 :	30 ✓½
60 l	40 l		Oxygen ✓½	by 10 litres

36. *Mass of Oxygen = 12 – 8.4 = 3.5g*

Element	Fe	O
Mass	8.4	3.6
R.A.M	56	16
No. of moles	$\frac{8.4}{56}$ 0.15	$\frac{3.6}{16}$ ✓ ½ 0.225 ✓ ½
Mole ration	$\frac{0.15}{0.15}$ 1 2	$\frac{0.225}{0.15}$ ✓ ½ 1.5 x2 3 ✓ ½

∴The empirical formula is Fe_2O_3