Gas laws

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

   $T \propto \frac{1}{\sqrt{MM}}$ **P**

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

   $\frac{T_1}{T_2}^2 = \frac{X}{32}$ **P**

   $\frac{28.3}{T_2}^2 = \frac{X}{32}$ **P**

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

   $X = 64$ **P**

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= $^1/_5$ x $\frac{100cm}{10sec}$
   = 2cm/sec **P** ½
   Rate of W = $\frac{10cm}{10sec}$
   = 1cm/sec **P** ½

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

   $\frac{2}{1}^2 = \frac{MW}{16}$

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

   $MW = 64$

3. *(a) The volume of a fixed mass of a gas is directly proportional to its absolute temperature at constant Pressure* **P**
   (b) Apply combined gas law; $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

   $V_1 = 3.5 \times 10^{-2}\ m^3$ $V_2 = 2.8 \times 10^{-2} m^3$

$P_1 = 1.0 \times 10^5 Pa$ $P_2 = 1.0 \times 105 Pa$ P ½

$T_1 = 291K$ $T_2 = ?$

$$T_2 = \frac{P_2 V_2 T_1}{P_1 V_1}$$

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

$T_2 = 232.8k$ P

4. $TsO_2 = \frac{R.M.N.SO_2}{}$ P½

TO_2 $R.M.MO_2$

SO_2 $= 32 + (16 \times 2) = 64$ p½

O_2 $= (16 \times 2)$ $= 32$ p½

$TsO_2 = \frac{64}{50}$ p½ $= \frac{}{32}$ $= 70.75$ p½

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

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

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

$(RSO_2)^2 = \frac{2.25x36.5}{64}$

$RSO_2 = \sqrt{\frac{2.25x36.5}{64}}$

$1.133\ cm/\ sec$

$1.133\ cm^3$ _____ $1\ sec$

$42\ cm^3 = \frac{42x1}{1.133}$

$= 37\ sec$

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

b)

c) $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ Ö ½ $V_2 = \frac{P_1V_1}{T_1} X \frac{T_2}{P_2}$ Ö ½

$\frac{250X273-23}{273 + 127}$ Ö ½

$= 156.5cm^3$

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

$= 100kg.$ √½

∴ *100 kg of* $CaCO_3 \equiv 22.4dm^3$ *of* $CO_2(g)$

1000 kg ” ” ?

= 22.4x1000 √1 = 224 dm³ √½
100

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

\ $x = \frac{740x200x248}{296 \times 780}$

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

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

\ $\frac{12}{7.2} = \sqrt{\frac{x}{16}}$ 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 2

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

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

⇒ $\frac{200}{T}^2 = \frac{11}{7}$

⇒ $\frac{T}{200} = \frac{7}{11}$

⇒ $T = 200.0.79772$ √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

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

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

$9 \quad 17$

$9x = 17$

$x = {}^{17}/_{9}$

$x = 1.88$

$Q = It$

$= 5 \times 386 = 1930C$

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

If $2 \times 96500C = 207$ (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. $\frac{TNH_3}{TB}$ $\frac{MNH_3}{MB}$ Ö ½

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

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

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

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

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

$V2 = \frac{400x1x5}{2 x246}$

$= 4.065\ dm^3$

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

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

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

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

$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{740mmHgx200cm^3x248K}{296K \times 780\ mm\ Hg}$

$= 158.97\ cm^3$

b) 60 l $p1$

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) $\frac{TimeCO_2}{Time\ NO_2} = \frac{\sqrt{M_rCO_2}}{M_rNO_2}$

Where $100cm^3$ of CO_2 takes 30 seconds

\ $150cm3$ of CO_2 takes $^{30}/_{100}$ x 150

= 45 seconds√

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

$\frac{45}{} = \ddot{O}\frac{44}{} \quad TNO_2 = \frac{45}{}$

$TNO_2 \quad 46 \quad 0.978$

$TNO_2 = 46 \text{ sec}$

OR

$\frac{RCO_2}{} = \ddot{O}\frac{M_rNO_2}{}$

RNO_2 M_rCO_2

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

$\frac{3.33}{RNO_2} = \frac{Ö46}{44}$

$= 1.0225$

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

$= 3.26\ cm^3$ per second

Time for No $= \frac{150cm^3}{3.26cm\ sec^{-1}} = 46$ 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 $= \frac{8}{40} = 0.2M$ P

Moles of NaOH in 25cm3

$\frac{25x0.2}{1000} = 0.005$ P

Mole ratio 1:2

Moles of acid $= \frac{0.005}{2}$

$= 0.0025$

$\frac{1x0.245}{0.0025} = 98$ P

3. No. Of moles of HNO_3 acid

$\frac{50x2}{1000} = 0.1$moles

Mole ratio 1:1 P

The KOH will have 0.1moles; $\frac{0.1X100}{50} = 0.2$moles

Then D grams is 0.2 X 56

$= 11.2g$

4. Number of moles of Q $= \frac{960cm^3x1mole}{24000cm^3}$

= 0.04moles

Equation:

$Na_2SO_{3(s)} + 2HCL_{(aq)} \quad 2NaCl_{(aq)} + SO_{2(g)} + H_2O_{(l)}$

Mole ratio Na_2SO_3 : SO_2 is 1:1

\ No. of moles of Na_2SO_3 = 0.04moles

Mass of $Na_2SO_3 = 126gmol^{-1} \times 0.04$

= 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:

$$\frac{0.5x72}{325} = 0.11078 \text{ litres}$$

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

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

$$\text{Molarity} = \frac{1000x0.2625}{5000} = 0.525M$$ P ½

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

$150cm^3$ = ? P

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

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

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

R.F.M of $MgCl_2$ = 24 + 71
= 95
Moles of Mass = $\frac{1.7}{R.F.M\ 95}$
= 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

$$0.03578\text{moles} = \frac{0.03578x6.0x10^{23}}{1}$$

= 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***

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

$X = \underline{2.4x24000} = 1200cm3$

$2(2.4)$

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

\ 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 = $\frac{0.1X300}{1000}$ = 0.03 mole

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

I : 2

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

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

$X = \frac{2.4x24000}{2(2.4)}$ = 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 $250cm^3 = 0.025 \times {}^{1000}/_{250} = 0.1$

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

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 = $\frac{\text{Answerin(c)(ii)}}{1000} \times \frac{2}{2}$

$= \frac{26}{1000} = 0.026$ √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. $NH_{(g)} + HNO_{(g)} \rightarrow NH_4NO_{3(s)}$ P 1

RMM of $NH_4NO_3 = 80$

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

RMM of $NH_3 = 17$

Mass of $NH_3 = 60 \times 17 = 1020$KJ 1

22. From the equation of step 3

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

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

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

178 kg " " " " " " $\frac{178X1000X22.4L}{178g}$ Ö 1 ½ mark

= 22,4000 liters Ö 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 Ö ½ mark

- Use value in d(ii) above

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

OR $\frac{4000X480}{}$ = 48,000cm3 Ö ½ mark

$40cm^3$
i.e. $\underline{Answer\ in\ e(i) X 480cm^3}$
Answer in d(i) *[Total = 11 marks]*

24. *(i)* $\frac{35.2x1000}{100 \times 16}$ P ½
$= 10Moles$ P ½
Or mass of $CH_4 = \frac{35.2x5}{1000} = 1.76g$ P ½
Mass in g $= 1.76 \times 1000 = 1760kg$ P ½

Moles of methane $= \frac{1760}{16}$ P ½
$= 110Moles$ P ½

(ii) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ – *(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*
$= 0.047 \times 24$
$= 1.128dm^3$ P 1
P 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.

$Na_2CO_3 \cdot x H_2O$	Na_2CO_3 +	H_2O √1	
34.8g	*15.9g*	*18.9g*	
	106	*18*	
	0.15 √1	*1.15*	*3*
	0.15	*0.15*	
	x =	*7* √1	

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	
85.5	***14.5***	
106	***18***	***(½mk)***
0.8066	***0.8055***	
0.8055	***0.8055***	***(½mk)***

$n = 1\ (Na_2CO_3.H_2O)$ (½mk)

29. Moles of $Na_2CO_3 = \frac{20x0.1}{1000} = 0.002$ 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 $H_2SO_4 = \frac{10000x0.002}{13} = 0.154$ 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^oC

Boiling point = 100^oC

Change in temperature, $\Delta T = 100-25 = 75^oC$ ½ mk

ΔT X mass X C = Q $315V = 112500$

$= \frac{75XVX4.2}{1000} = 112.5$ $V = \frac{112500}{315}$ ½ mk

$V = 357.km^3$ ½ mk

32. $RFM\ Na_2CO_3 = 43 + 12 + 48 = 106$

$Mol.\ Na_2CO_3 = \frac{19.6}{106} = 0.8149057$

$Molarity\ of\ Na_2Co_3 = \frac{0.1849057}{0.25} = 0.73962m$

$Na_2Co_{3(aq)} + MgCl_{2(aq)} + MgCo_{3(s)}$

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 = $\frac{0.1849X1000}{2}$
= 92.45 or 92.5 cm^3

33. ***i)*** ***ACID*** ***BASE***

1 *2*

½ 0.004 *$\frac{20cm^3}{1000cm^3}$ X 0.2 moles = 0.004 moles*

= 0.002 moles Ö ½

$25cm^3$ ——— 0.002 moles Ö ½
$1000cm^3$ ——— ?

$1000cm^3$ X 0.002 moles = 0.08 MÖ ½

ii) *0.08 moles ——— 10.08_g $H_2C_2O_4xH_2O$ Ö ½*
1 mole ——— ?

$\frac{1mole}{0.08\ moles}$ X 10.08 = 126 Ö ½

126 ——— $H_2C_2O_4xH_2O$

18x = 126 – 90 Ö ½
18x = 36
X = 2 Ö ½

34. *$Mg_{(g)}$ + 2HCL $_{(aq)}$ ——— $MgCl_{2\ (aq)}$ + $H_{2\ (g)}$*
24g ——— $22.4dm^3$
16g ——— ?

$\frac{1.6g}{}$x $22.4dm^3$ Ö 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 P½
60 l 40 l Oxygen P½ 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	*8.4*	*3.6* P ½

	56 ***0.15***	***16*** ***0.225*** P ½
Mole ration	***0.15*** ***0.15*** ***1*** ***2***	***0.225*** ***0.15*** P ½ ***1.5*** ***x2*** ***3*** P ½

**** ***The empirical formula is*** Fe_2O_3