BOLTON
SCHOOL
BOYS' DIVISION

Chemistry:
Transition from GCSE to AS level

Part 5 - Moles and Gases

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(ii) Moles and gases

At GCSE the molar volume of a gas
at room temperature and pressure
= 24 dm^3 = 24,000 cm^3
What exactly are room temperature & pressure?

For A level, we use the ***ideal gas equation***
pV = nRT

Ideal gas equation $pV = nRT$

p = pressure of the gas in Pa (Nm^{-2})

V = volume in m^3

n = number of moles of gas

R = gas constant (8.31 $J\ K^{-1}\ mol^{-1}$)

T = temperature in Kelvins

(add 273 to the temperature in $^{\circ}$C)

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Problems with units?

Remember a metre rule

1m	10 dm	100cm

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1m	10 dm	100cm
1^3 m^3	10^3 dm^3	$(100)^3$ cm^3

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1m	10 dm	100cm
$1^3\ m^3$	$10^3\ dm^3$	$(100)^3\ cm^3$
$1\ m^3$	$10^3\ dm^3$	$10^6\ cm^3$

Using pV=nRT

$$n = \frac{pV}{RT}$$

e.g. for 200 cm^3 of hydrogen at 25 °C and 100 kPa

the number of moles of hydrogen,

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e.g. for 200 cm^3 of hydrogen at 25 °C and 100 kPa the number of moles of hydrogen,

$$n = \frac{pV}{RT} = \frac{100{,}000 \times (200 \times 10^{-6})}{8.31 \times 298}$$

Using pV=nRT

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e.g. for 200 cm^3 of hydrogen at 25 °C and 100 kPa the number of moles of hydrogen,

Pressure in Pa

Volume in m^3

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Temperature in Kelvins

Using pV=nRT

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e.g. for 200cm^3 of hydrogen at 25 °C and 100 kPa the number of moles of hydrogen,

Pressure in Pa

Volume in m^3

$$n = \frac{pV}{RT} = \frac{100{,}000 \times (200 \times 10^{-6})}{8.31 \times 298}$$

Temperature in Kelvins

= **0.00808 mol (or 8.08 × 10^{-3} mol)**

If the mass of a known volume of gas is known then its M_r can be found

(i) 0.123g of gas has volume 65.5 cm^3 (measured at 99 °C and 100 kPa) Find its M_r

$$n = \frac{pV}{RT} = \frac{100{,}000 \times (65.5 \times 10^{-6})}{8.31 \times 372}$$

$$= 2.119 \times 10^{-3} \text{ mol}$$

$$M_r = \frac{\text{mass}}{\text{moles}} = \frac{0.123}{2.119 \times 10^{-3}} = 58.05$$

$\therefore$ **M_r = 58.1 (3sig figs)**

(ii) Find the volume of 0.100 mol of carbon dioxide at 25 °C and 100 kPa AQA

$$V = \frac{nRT}{p} = \frac{0.100 \times 8.31 \times 298}{100{,}000}$$

= 2.48×10^{-3} m^3 or 2.48 dm^3 (3 sig figs)

Try these before you attempt questions on the gas equation

Converting Units

Convert the following quantities into the units specified.

Give your answers in standard form.

0.347 m^3	cm^3	
0.520 dm^3	cm^3	
321.9 dm^3	m^3	
100 cm^3	dm^3	
20.52 cm^3	m^3	
3.59 dm^3	m^3	
0.0023 m^3	cm^3	
2579 cm^3	dm^3	
15.97 dm^3	m^3	
2.96 m^3	cm^3	

Pause this presentation while you complete the exercise on the previous page.

When complete move to the next page where you can check your answers.

Care - answers are in standard form !

Converting Units

Convert the following quantities into the units specified:

0.347 m^3	cm^3	3.47×10^5 cm^3
0.520 dm^3	cm^3	5.20×10^2 cm^3
321.9 dm^3	m^3	3.219×10^{-1} m^3
100 cm^3	dm^3	1.0×10^{-1} dm^3
20.52 cm^3	m^3	2.052×10^{-5} m^3
3.59 dm^3	m^3	3.59×10^{-3} m^3
0.0023 m^3	cm^3	2.3×10^3 cm^3
2579 cm^3	dm^3	$2.579\ (\times 10^0)$ dm^3
15.97 dm^3	m^3	1.597×10^{-2} m^3
2.96 m^3	cm^3	2.96×10^6 cm^3

The Periodic Table of the Elements

Key

relative atomic mass
symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	*(18)*
							1.0 **H** hydrogen 1										4.0 **He** helium 2
6.9 **Li** lithium 3	9.0 **Be** beryllium 4											10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12											27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	96.0 **Mo** molybdenum 42	[97] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La** * lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac** † actinium 89	[267] **Rf** rutherfordium 104	[270] **Db** dubnium 105	[269] **Sg** seaborgium 106	[270] **Bh** bohrium 107	[270] **Hs** hassium 108	[278] **Mt** meitnerium 109	[281] **Ds** darmstadtium 110	[281] **Rg** roentgenium 111	[285] **Cn** copernicium 112	[286] **Nh** nihonium 113	[289] **Fl** flerovium 114	[289] **Mc** moscovium 115	[293] **Lv** livermorium 116	[294] **Ts** tennessine 117	[294] **Og** oganesson 118

* **58 – 71** Lanthanides	140.1 **Ce** cerium 58	140.9 **Pr** praseodymium 59	144.2 **Nd** neodymium 60	[145] **Pm** promethium 61	150.4 **Sm** samarium 62	152.0 **Eu** europium 63	157.3 **Gd** gadolinium 64	158.9 **Tb** terbium 65	162.5 **Dy** dysprosium 66	164.9 **Ho** holmium 67	167.3 **Er** erbium 68	168.9 **Tm** thulium 69	173.0 **Yb** ytterbium 70	175.0 **Lu** lutetium 71
† **90 – 103** Actinides	232.0 **Th** thorium 90	231.0 **Pa** protactinium 91	238.0 **U** uranium 92	[237] **Np** neptunium 93	[244] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[247] **Bk** berkelium 97	[251] **Cf** californium 98	[252] **Es** einsteinium 99	[257] **Fm** fermium 100	[258] **Md** mendelevium 101	[259] **No** nobelium 102	[262] **Lr** lawrencium 103

Use this for the task on the next page

The Ideal Gas Equation

1. Krypton has a density of 3.44 g dm^{-3} at 298K and 1.01×10^5 Pa.
   Calculate its relative atomic mass.

   ....

   ....

   ....

2. A gas X has a density of 8.96×10^{-2} g dm^{-3} at 0°C and 1.01×10^5 Pa.
   Calculate its relative molecular mass and suggest a possible identity for X.

   ....

   ....

   ....

3. 0.71 g of a gas Y has a volume of 821 cm^3 at 227°C and 0.5×10^5 Pa.
   Calculate its relative molecular mass and suggest a possible identity for Y.

   ....

   ....

   ....

4. Ammonium nitrite will decompose completely at 150°C as follows:

   $$NH_4NO_2 \text{ (s)} \quad \rightarrow \quad N_2 \text{ (g)} \quad + \quad 2\ H_2O \text{ (g)}$$

   If 0.01 moles of ammonium nitrite are heated at 150°C and 1.01×10^5 Pa, what volume of gas would be formed? (Assume the volume was measured at this temperature and pressure)

   ....

   ....

   ....

Molar Gas Constant, R = 8.31 J K^{-1} mol^{-1}

Pause this presentation while you complete the exercise on the previous page.

When complete move to the next page where you can check your answers.

The Ideal Gas Equation

$3.44 \times 10^3\ g\,m^{-3}$

1. Krypton has a density of 3.44 g dm^{-3} at 298K and 1.01 x 10^5 Pa.
   Calculate its relative atomic mass.

$pV = nRT = \left(\frac{mass}{A_r}\right)RT \quad \therefore A_r = \left(\frac{mass}{volume}\right)\frac{RT}{p} = density\frac{RT}{p}$

$density,\ d = \frac{mass}{volume} \quad \therefore A_r = \frac{3.44 \times 10^3 \times 8.31 \times 298}{1.01 \times 10^5} = 84.3\ (1dp)$

tough!

2. A gas X has a density of 8.96 x 10^{-2} g dm^{-3} at 0°C and 1.01 x 10^5 Pa.
   Calculate its relative molecular mass and suggest a possible identity for X.

$M_r = density\ \frac{RT}{p}$

$= \frac{8.96 \times 10^{-2} \times 10^3 \times 8.31 \times 273}{1.01 \times 10^5} = 2.0\ (1dp) \quad \therefore$ Hydrogen (H_2)

3. 0.71 g of a gas Y has a volume of 821 cm^3 at 227°C and 0.5 x 10^5 Pa.
   Calculate its relative molecular mass and suggest a possible identity for Y.

$M_r = \frac{mass\ RT}{pV} = \frac{0.71 \times 8.31 \times 500}{0.5 \times 10^5 \times 821 \times 10^{-6}}$

$= 71.9\ (1\ dp)$ chlorine (Cl_2)
(has $M_r = 71.0$)

4. Ammonium nitrite will decompose completely at 150°C as follows:

$$NH_4NO_2\ (s) \rightarrow N_2\ (g) + 2\ H_2O\ (g)$$

If 0.01 moles of ammonium nitrite are heated at 150°C and 1.01 x 10^5 Pa, what volume of gas would be formed? (Assume the volume was measured at this temperature and pressure)

$V = \frac{nRT}{p} = \frac{0.03 \times 8.31 \times 423}{1.01 \times 10^5} = 1.04 \times 10^{-3}\ m^3\ (3sf)$

Molar Gas Constant, R = 8.31 J K^{-1} mol^{-1}

Having checked your work you will have either:

1. Completed the task correctly - well done :)

2. Made some mistakes - which you now understand (having seen the correct answer) - that's OK as you have 'learned from your mistakes'

3. Do not understand the answer - if this is the case you **must** seek assistance from your teacher (if you do not then you will ***never*** understand this and this may be a building block for later work!)

When you’re confident with this topic move onto part 6:

Solutions