Triple - Chemistry - Key Stage 4

Quantitative Chemistry

Titration calculations

Mrs. Begum

Periodic Table of Elements

Key:

relative atomic mass → 1
H ← Atomic symbol
Name → hydrogen
1 ← Atomic (proton number)

1 **H** hydrogen 1																	4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[97] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **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 87	[285] **Cn** copernicium 112	[286] **Nh** nihonium 113	[289] **Fl** flerovium 114	[289] **Mc** moscovium 115	[293] **Lv** livermorium 116	[293] **Ts** tennessine 117	[294] **Og** organesson 118

* The lanthanides (atomic numbers 58 - 71) and the Actinides (atomic numbers 90 - 103) have been omitted.

Relative atomic masses for **Cu** and **Cl** have not been rounded to the nearest whole number.

Warm up

- What do we mean by ‘concentration’?
- What are the units for concentration?
- How many cm^3 in 1 dm^3?
- If a solution has a concentration of 1.5 mol/dm^3, how many moles are in 22 cm^3?
- What is the concentration of a solution that has 0.02 moles in 20 cm^3?

Task 1

Calculate the mean and the uncertainty in these two sets of values:

Attempt	Volume of acid added (cm^3)
1	12.5
2	12.4
3	12.7
4	12.5
5	12.8

Attempt	Volume of acid added (cm^3)
1	23.7
2	23.5
3	23.7
4	23.8
5	23.2

Task 2

1. 15.7 cm^3 of HCl completely neutralised 25 cm^3 of LiOH. The HCl was 2 mol/dm^3.

   The equation is : $LiOH + HCl \longrightarrow LiCl + H_2O$

   Calculate the concentration of the LiOH.

2. In a titration, 25.00 cm^3 of a solution of hydrochloric acid reacted with 18.40 cm^3 of sodium hydroxide solution of concentration 0.15 mol/dm^3.

   The equation which represents the reaction is:

   $HCl + NaOH \longrightarrow NaCl + H_2O$

   Calculate the concentration of hydrochloric acid in mol/dm^3

Task 3

15.8 cm^3 of H_2SO_4 completely neutralised 20 cm^3 of NaOH. The NaOH was 1.5 mol/dm^3.

The equation is : $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$

Calculate the concentration of the of H_2SO_4.

Question 1

A student titrated 20 cm^3 portions of dilute sulfuric acid with a 0.205 mol/dm^3 sodium hydroxide solution.

The table below shows the student's results:

Titration	**1**	**2**	**3**	**4**	**5**
Volume of sodium hydroxide solution in cm^3	21.50	19.10	20.10	20.15	20.15

The equation for the reaction is: $2\ NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + 2\ H_2O$

- Calculate the concentration of the sulfuric acid in mol/dm^3.

  Use only the student's concordant results.

  Concordant results are those within 0.10 cm^3 of each other.

Warm up answers

- What do we mean by 'concentration'? **The mass of dissolved solute per unit volume**
- What are the units for concentration? **g/dm^3 or mol/dm^3**
- How many cm^3 in 1 dm^3? **1000 cm^3 in 1 dm^3**
- If a solution has a concentration of 1.5 mol/dm^3, how many moles are in 22 cm^3? **0.033 moles**
- What is the concentration of a solution that has 0.02 moles in 20 cm^3? **1 mol/dm^3 (1 M)**

Task 1 answers

Calculate the mean and the uncertainty in these two sets of values:

Attempt	Volume of acid added (cm^3)
1	12.5
2	12.4
3	12.7
4	12.5
5	12.8

Attempt	Volume of acid added (cm^3)
1	23.7
2	23.5
3	23.7
4	23.8
5	23.2

Mean = (12.5 + 12.4 + 12.5) / 3 = 12.5
Uncertainty = (12.5 - 12.4) / 2 = 0.05

Mean = (23.7 + 23.7 + 23.8) / 3 = 23.7
Uncertainty = (23.8 - 23.7) / 2 = 0.05

Task 2 answers

1. 15.7 cm^3 of HCl completely neutralised 25 cm^3 of LiOH. The HCl was 2 mol/dm^3.

   The equation is : $LiOH + HCl \longrightarrow LiCl + H_2O$

   Calculate the concentration of the LiOH.

   Convert 14.8cm^3 in dm^3 = 14.8 / 1000 = 0.0148 dm^3

   Moles = 2 x 0.0148 = 0.0296

   Concentration = 0.0296 / 0.02 = $\boxed{1.48\ mol./dm^3}$

Task 2 answers

2. In a titration, 25.00 cm^3 of a solution of hydrochloric acid reacted with 18.40 cm^3 of sodium hydroxide solution of concentration 0.15 mol/dm^3.

   The equation which represents the reaction is:

   $$HCl + NaOH \longrightarrow NaCl + H_2O$$

   Calculate the concentration of hydrochloric acid in mol/dm^3

   Convert 19.4 cm^3 in dm^3 = 19.4 / 1000 = 0.0194 dm^3

   Moles = 0.15 x 0.0194 = 0.00291

   Concentration = 0.00291 / 0.02 = $\boxed{0.146\ mol./dm^3}$

Task 3 answers

15.8 cm^3 of H_2SO_4 completely neutralised 20 cm^3 of NaOH. The NaOH was 1.5 mol/dm^3.

The equation is : $2NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$

Calculate the concentration of the of H_2SO_4.

Convert 20 cm^3 to dm^3 = 20 / 1000 = 0.02 dm^3

Moles NaOH = 1.5 x 0.02 = 0.03

Ratio NaOH : H_2SO_4 = 2 : 1

Moles NaOH : H_2SO_4 = 0.03 : 0.015

Concentration H_2SO_4 = 0.015 / 0.0158 = 0.95 mol/dm^3

Question 1 answers

- Choose titrations 3, 4, 5

- Average volume of NaOH   = 20.13 (cm^3)

- (calculation):
  (moles NaOH = (20.13 /1000) x 0.205
  = 0.0041

- (moles H_2SO_4 =
  ½ × 0.0041 =) 0.00206

- (concentration = 0.00206 / (20 / 1000)

  = **<u>0.103 mol/dm</u>^{3}**