No Brain Too Small

Level 1 Science Practice Exam 1 ANSWERS

90944 Demonstrate understanding of aspects of acids and bases

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of aspects of acids and bases.	Demonstrate in-depth understanding of aspects of acids and bases.	Demonstrate comprehensive understanding of aspects of acids and bases

You should attempt all the questions in this booklet.

A table of ions (page 2) and periodic table (page 14) are included.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Table of ions

+1	+2	+3	–3	–2	–1
NH_4^+	Ca^{2+}	Al^{3+}		O^{2-}	OH^-
Na^+	Mg^{2+}	Fe^{3+}		S^{2-}	Cl^-
K^+	Cu^{2+}			CO_3^{2-}	NO_3^-
Ag^+	Pb^{2+}			SO_4^{2-}	HCO_3^-
H^+	Fe^{2+}				
Li^+	Ba^{2+}				
	Zn^{2+}				

Question One: Atoms, Ions and Formulae.

(a) Explain why magnesium (Mg) is in Group 2 and Period 3 of the Periodic table.

Magnesium with an atomic number of 12 is in Group 2 as it has 2 electrons in its valence (outermost) shell.

Its 12 electrons are arranged 2.8.3. This is why it is placed in period 3 as its valence electrons are filling the 3rd energy level / shell.

(b) Explain why a magnesium atom has no overall charge.

Magnesium has an atomic number of 12 which means it has 12 protons (in its nucleus). Protons have a + charge. As an atom it has 12 electrons; electrons have a – charge.

With 12 protons (12+) and 12 electrons (-) it has a net charge of zero; the atom has no overall charge.

(c) Complete the table below for the ions formed by aluminium, sodium and oxygen. Use the Periodic Table in the Resource Booklet to help you.

Atom	Atomic number	Electron arrangement of atom	Electron arrangement of ion	Charge on ion
Al	13	2, 8, 3	2, 8	3+
Na	11	2, 8, 1	2, 8	1+ (or +)
O	8	2, 6	2, 8	2-

(d) The formula for aluminium oxide is Al_2O_3. The formula for sodium oxide is Na_2O. Explain why the two formulae are different.

In your answer:

- consider the ratio of ions in each formula and explain how the ratio is related to the charge on the ions
- relate the ion ratio in the ionic formula to the number of electrons lost or gained by each atom.

Aluminium forms a 3+ ion when the aluminium atom loses 3 electrons to form a full valence shell, a stable arrangement.

Oxygen forms a 2- ion when it gains 2 electrons to achieve a full valance shell.

Aluminium oxide is Al_2O_3. The ions combine in a ratio so that there is no overall charge on the ionic compound. (2 x 3+) + (3 x 2-) = 0. This is why the ions Al^{3+} and O^{2-} are in a 2 : 3 ratio.

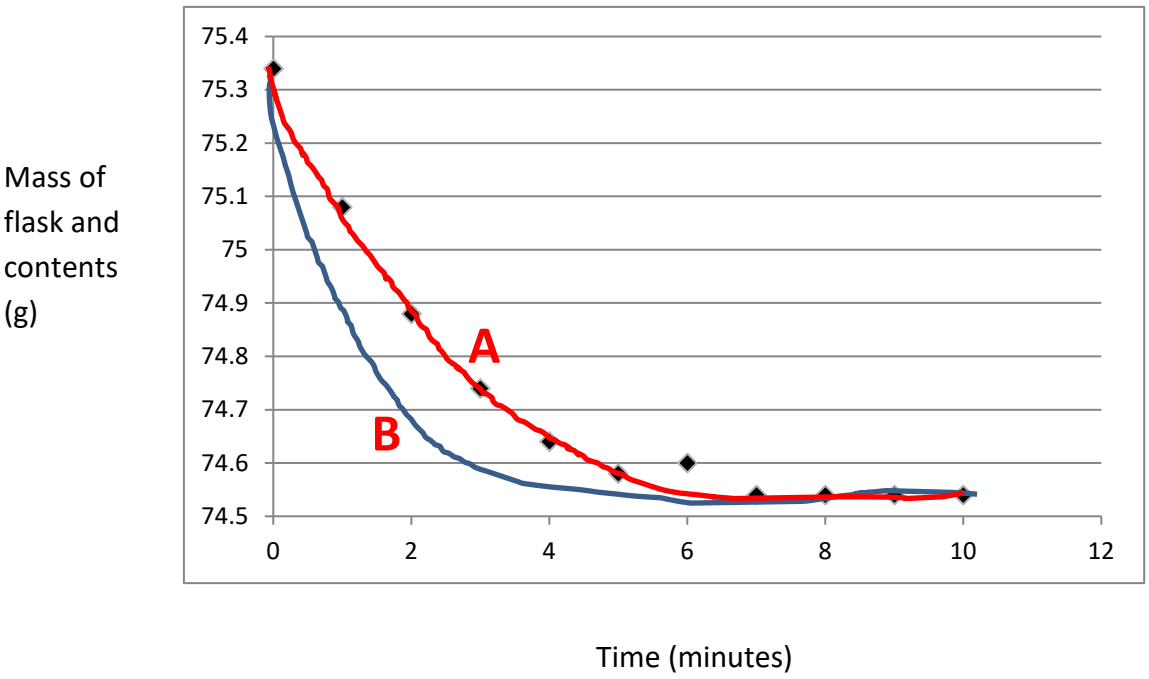
Sodium forms a 1+ ion as it only loses one electron to achieve a full valence shell.

The formula of sodium oxide is Na_2O. (2 x 1+) + (1 x 2-) = 0. So the ratio of Na^+ ions to O^{2-} ions is 2 : 1 so that's why the formula is Na_2O.

Question Two: Reaction Rates

Calcium carbonate reacts with dilute hydrochloric acid to produce the gas carbon dioxide.

The graph below shows the results from a reaction when 40 mL of dilute hydrochloric acid was added to one marble chip (calcium carbonate) at room temperature of 20°C. The calcium carbonate was in excess.



(a) Draw a smooth curve through the reliable points and label it A.

(b) Sketch on the grid the graph that would be obtained if the same reaction was carried out at 40°C. Label it B.

(c) Explain your answer to (b) in terms of particle collisions.

At the higher temperature the acid particles are moving faster and therefore collide more often with the marble chips. The more collisions/time the greater the rate of the reaction. Line B is steeper as more gas is produced/time and so the mass of the flask and contents decreases faster (as more gas escapes/time).

Also at the higher temperature the acid particles have more kinetic energy and so more of the collisions/time are successful collisions. Particles need a certain amount of energy before collisions are successful or effective collisions – collisions that lead to a reaction. By increasing the energy of the acid particles, more collisions/time are successful and so the rate of reaction increases. Gas is lost faster from the flask and the decrease in mass occurs faster, as seen by line B.

(d) Write a word equation AND a balanced symbol equation for the reaction between calcium carbonate and hydrochloric acid.

Word equation:

calcium carbonate + hydrochloric acid → calcium chloride + water + carbon dioxide

Balanced symbol equation:

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Question Three: Salts

Epsom salts was a favourite medicine of our grandparents.

Its chemical name is magnesium sulfate.

(a) Write down the chemical formula of magnesium sulfate.

$MgSO_4$

Salts can be made in a number of ways.

I. adding excess metal to an acid
II. adding excess carbonate to an acid
III. adding excess hydroxide to an acid

(b) For each of the methods above, give the correct **chemical formulae** of two substances which could be mixed to make magnesium sulfate.

method I.
Mg and H_2SO_4

method II.
$MgCO_3$ and H_2SO_4

method III.
$Mg(OH)_2$ and H_2SO_4

(c) In each case the magnesium sulfate is formed as a solution in water. A little unreacted metal, carbonate or hydroxide also remains in the mixture.

What would you need to do to produce a pure sample of solid magnesium sulfate?

Filter the mixture to remove the excess / unreacted solid (metal, carbonate or hydroxide).

Evaporate the filtrate slowly (in an evaporating basin over a Bunsen burner) to produce crystals of pure magnesium sulfate OR leave the magnesium sulfate solution in a dish in a warm/sunny place until the water has all evaporated, forming crystals of pure magnesium sulfate.

NOTE: If you don't filter the salt will be contaminated with particles of Mg, $MgCO_3$ or $Mg(OH)_2$

A student is asked to neutralise 10 mL of nitric acid solution. They add 3 drops of universal indicator solution. They are given some dilute sodium hydroxide solution which they add, drop by drop.

(d) Write a word equation AND a balanced symbol equation for the reaction between nitric acid and sodium hydroxide.

Word equation:

sodium hydroxide + nitric acid → sodium nitrate + water

Balanced symbol equation:

$NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$

(e) Discuss what occurs during neutralisation of the nitric acid.

In your answer you should:

- discuss the observations you would expect to make during the neutralisation
- explain the relationship between the changing pH of the solution and the amount of hydrogen and hydroxide ions as the sodium hydroxide is added to the beaker.

Nitric acid is an acid (the solution contains more H^+ ions than OH^- ions). When universal indicator is added it turns red which indicates that the solution is an acid.

Sodium hydroxide is an alkali (contains more OH^- ions than H^+ ions).

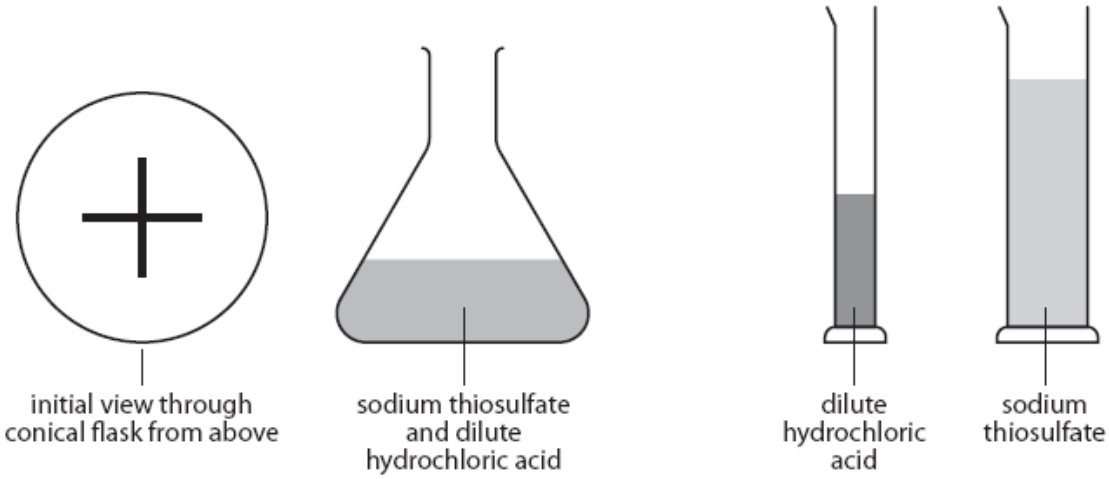
As the sodium hydroxide is added to the nitric acid, the OH^- ions react with some of the H^+ ions; $H^+ + OH^- \rightarrow H_2O$. The pH starts to rise as H^+ ions are removed.

As more and more OH^- is added the concentration (amount/mL) of hydrogen ions decreases and the pH continues to rise. As the pH rises the colour of UI changes from red to orange to yellow and then to green. Once it is green this shows that neutralisation has occurred and the amount of added OH^- ions is equal to the amount of H^+ ions from the nitric acid. The solution is neutral, pH 7.

Question Four: Rates

When sodium thiosulfate solution, $Na_2S_2O_3(aq)$, is added to hydrochloric acid, yellow sulfur is formed.

When viewed from above the **+** disappears from view, as more and more sulfur is formed.



The following results table was obtained by mixing various amounts of sodium thiosulfate solution, water and 1 mol L^{-1} hydrochloric acid.

Volume (mL)	$Na_2S_2O_3$	50	40	30	20	10
	H_2O	0	10	20	30	40
	HCl	6	6	6	6	6
Reaction time (s)		7	15	29	58	182

Discuss this experiment.

In your answer you should:

- identify which variable is being altered
- explain why the volume of acid needs to be kept the same
- describe what was measured during the reaction to get the data above
- write a conclusion for this experiment which refers to particle collisions.

In this experiment the concentration of sodium thiosulfate is being altered (by diluting it with water). Adding water decreases its concentration.

The volume of acid needs to be kept the same otherwise it would not be a fair experiment; having more or less acid particles would also affect the number of collisions/s between the sodium thiosulfate and acid, and therefore the time for the mixture to become cloudy and hide the + from view.

To get the data the students measured the time, in seconds, for the + to disappear from view when viewed from above. The yellow sulfur formed hides the +. The faster it was hidden the greater the rate of reaction.

Concentration refers to the amount of particles/ unit volume. The more particles of sodium thiosulfate/mL, the greater its concentration. The conclusion is: as the concentration of sodium thiosulfate decreases the rate of reaction also decreases. This can be seen by the fact that the + was hidden fastest (7 s) when the sodium thiosulfate solution was the most concentrated, and slowest (182 s) when it was most dilute.

This is because when the sodium thiosulfate was most concentrated there were more sodium thiosulfate particles/ mL and so there were more collisions/s between the sodium thiosulfate particles and the acid particles – and so the rate of reaction was greatest.

EXTRA PAPER

PERIODIC TABLE OF THE ELEMENTS

1	2											13	14	15	16	17	18
																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	3	4	5	6	7	8	9	10	11	12	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg							

Atomic Number