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Suggested answers to 2015 O level Chemistry Paper 2 5073

Section A

1 (a)

Element	Oxidation state	Metal/Non-Metal
A	-2	Non-metal
B	+2, +3, +4, +6, +7	Metal
C	+1	Non-metal
D	+3	Metal
E	-1	Non-metal

(b) (i) Element C is hydrogen?

Teacher's Comments: Hydrogen is the only known *non-metal* to form a cation, H^+.

(ii) Element A is in Group 6?

Teacher's Comments: Group 6 elements have six valence electrons and thus must *gain* two to fulfill the octet configuration, forming a charge of 2-.

(iii) Element B forms coloured compounds?

Teacher's Comments: Transition metals can exhibit variable/multiple oxidation states, and thus exist as coloured compounds.

(c) Elements from Group 0 do not appear in the above table as they are inert and do not form compounds, and thus do not exhibit any oxidation states.

Teacher's Comments: The Noble Gases already have a full valence shell fulfilling the duplet/octet rule and thus do not need to react, unlike the other elements.

2 (a) A trend in the reduction temperature with the reactivity of the metal is that the more reactive the metal, the higher the reduction temperature of its oxide.

Teacher's Comments: As a metal's reactivity increases, it will form stronger ionic bonds with oxygen, which will in turn require larger amounts of energy to break for the metal ion to be reduced.

(b) The predicted temperature to reduce iron oxide is 900 °C

(c) The reaction between Mg and AgO would be the most vigorous as the difference in the reactivity of Mg and Ag is the greatest.

(d) When Zn reacts with steam, ZnO and H_2 are formed.

3 (a)

Organic compound	**Manufacturing process**
Ethene	Fractional distillation of crude oil/petroleum and catalytic cracking.
Polyethene	Addition polymerisation of ethene
Ethanol	Process 1 Catalysed hydration of ethene to ethanol Process 2 Fermentation of glucose
Ethanoic acid	Oxidation of ethanol

(b) A similarity in the reaction of dilute ethanoic acid + metal oxide & dilute HCl + metal oxide is that both reactions are neutralisations and will result in a formation of a salt and water.

OR

both reactions are neutralisations and will thus be exothermic.

(c) The rate of reaction of dilute HCl + metal oxide is faster than dilute ethanoic acid + metal oxide because HCl is a strong acid which fully dissociates in aqueous solution while CH_3COOH is a weak acid and only partially dissociates in aqueous solution. This means that for the same volume and concentration used of both acids, HCl would have the higher concentration of H^+, which leads to an increase its the rate of reaction over that of CH_3COOH.

Teacher's Comments: Recall the concept of strong and weak acids.

4 (a) A predicted melting point of aluminium is 650 °C.

Teacher's Comments: Impurities increase the melting point of pure substances. Thus, the melting point of Al will be lower than those given in the table. It will also be close to that of the shred Al-containing products as these would already have pure Al inside.

(a) It is 95% less energy efficient to extract Al from bauxite when compared with recycling because

(i) Recycling requires a lower operating temperature than extraction from bauxite.
(ii) It also does not require additional energy for the removal of impurities, unlike with bauxite.
(iii) Aluminium-containing products already have relatively pure aluminium in them, which further increases the efficiency of the recycling process, since it has already been purified before.

(b) It is important to recycle aluminium, rather than to extract it, as metals are a finite resource, extraction is an environmentally-damaging process, due to the use and inappropriate disposal of hazardous chemicals and scarring of the earth at the mining site.

(c) Untreated waste concentrated NaOH is highly caustic and can contaminate the environment by making soil too alkaline to farm on, and can kill aquatic life if it runs-off into water bodies. CO_2 is the major greenhouse gas in the atmosphere, and will exacerbate the cycle of global warming.

(d) (i) Duralumin is an alloy

(ii) Duralumin can be used to construct aircraft bodies because being an alloy, it has different sizes of atoms in the atomic arrangement, which disrupts the uniformity and order, resulting in the atoms being unable to slide over each other, and thus being stronger than pure metals.

5 (a) The following is an equation for the electrolysis of dilute NaCl.

Cathode: $2\ H^+\ (aq) + 2\ e^- \rightarrow H_2\ (g)$
Anode: $4\ OH^-\ (aq) \rightarrow O_2\ (g) + H_2O\ (l) + 4\ e^-$

(b) The theoretical ratio of the volume of H_2 : O_2 is 2 : 1 because for every oxide anion that discharges, two hydrogen cations can discharge, which translates to the theoretical ratio of H_2 : O_2 = 2 : 1.

(c) Initially, the ratio of oxygen to hydrogen is 1 : 2. As the electrolysis goes on, more water is electrolysed and the concentration of NaCl increases. Eventually, a concentrated solution of NaCl is obtained and chloride anions get preferentially discharged over hydroxide anions, with a chlorine to hydrogen ratio of 1 : 1

(d) If concentrated NaCl is used instead of dilute NaCl, Cl_2 will discharge at the anode instead of O_2.

(e) Platinum electrodes are used as they are inert to the O_2 that get discharged at the anode.

6

(a) Limestone is less alkaline than slaked lime or quicklime because limestone, a metal carbonate, is a weakly basic salt, unlike slaked lime or quicklime, which are strong bases. It thus dissociates partially in aqueous solution and produces less OH^- than the strong bases, which fully dissociate in aqueous solution.

(b) The advantages of using slag to lime soil is that slag is a by-product of the blast furnace purification of haematite, and is thus a cheap and abundant liming agent.

(c) The percentage by mass of calcium in quicklime when compared with limestone is

$A_r(Ca) = 40$
$M_r(\text{quicklime, } CaO) = 40 + 16 = 56.$
$M_r(\text{limestone, } CaCO_3) = 40 + 12 + 3(16) = 100$

$\%$ by mass of Ca in quicklime $= \frac{40}{56} \times 100\% = 71.42\%$
$\approx 71.4\%$ (3 sig. fig.)

$\%$ by mass of Ca in limestone $= \frac{40}{100} \times 100\% = 40\%$

$\therefore$ Quicklime has a greater % composition of Ca than $CaCO_3$.

(d) The volume of CO_2 released when 25 tonnes of limestone is reduced to calcium oxide is

$CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2$ $\qquad$ $CaCO_3 : CaO : CO_2$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad 1 : 1 : 1$

$n(CaCO_3) = \frac{25 \times 10^6}{100} = 25 \times 10^4$ mol
$\therefore n(CO_2) = 25 \times 10^4$ mol
$\therefore v(CO_2) = 25 \times 10^4 \times 24 = 600 \times 10^4\ dm^3$
$= 6 \times 10^6\ dm^3$

Section B

7 (a) Down the alkane homologous series, as molecular size of the alkanes increase, so too does the melting and boiling points of the alkanes.

(b) The predicted melting point and boiling point of heptane are
Melting point: -72 °C, boiling point: 100 °C

(c) The flashpoint of the alkanes increases as the molecular size of the alkanes increase.

(d) Isomerisation of the alkanes decreases their respective flashpoints. This can be seen from the decrease in the flashpoint of the straight-chain pentane from -49 °C to -57 °C and to a further -65 °C as the degree of branching of the isomers increase. This decrease is also evident between the straight-chain octane, with a flashpoint of 13 °C, and its branched isomer, with a flashpoint of 4 °C.

(e) In winter-blend petrol the pentane and 2,2-dimethylpropane added to usual petrol decreases the flashpoint of the overall blend, making it easier to combust in the cold winter temperatures, reducing the energy usage of motor petrol vehicles in winter.

(f) Since petrol tanks are not airtight, if a winter-blend petrol with a depressed flashpoint in comparison to regular petrol is used in hot-weather countries, the ambient daytime temperatures of these countries might be sufficient to cause this petrol blend to easily vapourize and escape from the petrol tank.

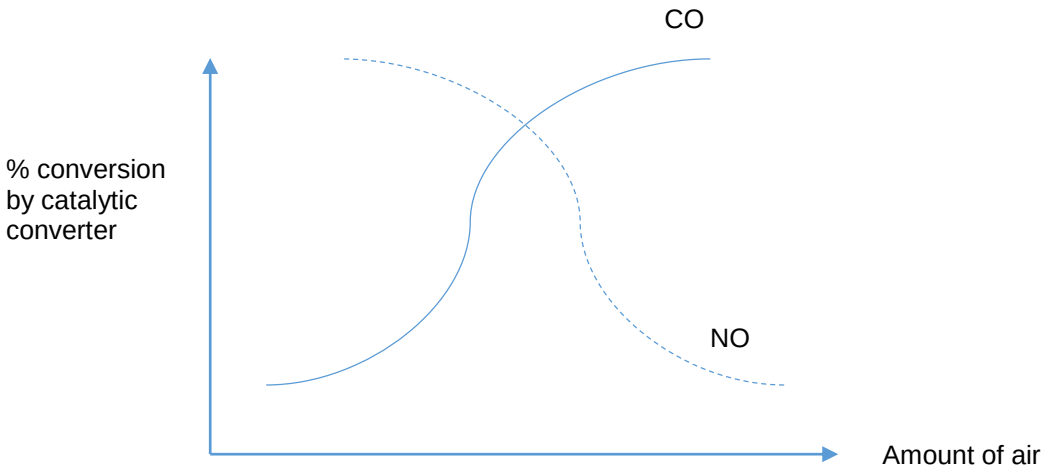
8 (a) Lean burn of petrol is better because

(i) it reduces hydrocarbon emission
(ii) it reduces CO emissions
(iii) it is more efficient by providing better fuel economy

(b) A reaction between CO & NO in the catalytic converter is

$$2NO + 2CO \rightarrow N_2 + 2CO_2$$

(C)



From the graph, as the amount of air supplied to an engine's combustion chamber increases, the percentage of NO converted to N_2 decreases and the percentage of CO converted to CO_2 increases.

9

(a) A jet of fluorine gas that is aimed at a piece of filter paper that is soaked in potassium bromide solution turns the filter paper brown because fluorine, being more reactive than bromine, will displace bromine from potassium bromide, liberating brown aqueous bromine and turning the filter paper brown.

$F_2(aq) + 2KBr(aq) \Rightarrow 2KF(aq) + Br_2(aq)$

If the jet is changed to chlorine, and then iodine I would expect the same colour change to happen, as with fluorine, as chlorine is also more reactive than bromine and the same displacement reaction will occur, also turning the filter paper brown.

However since iodine is less reactive than bromine and thus will not displace bromine from potassium bromide; no brown colouration will be observed on the filter paper.

(b) A chemical equation for the reaction between fluorine and iron is

$2\ Fe\ (s) + 3\ F_2\ (g) \rightarrow 2\ FeF_3\ (s)$

Since F is acting as an oxidising agent, it will get reduced in the reaction. F is reduced from an oxidation state of 0 in F_2 to an oxidation state of -1 in FeF_3. The reduction of F occurs as one Fe atom transfers one electron to each one of the three different F atoms.