2017 J2 H1 Chemistry Prelim Answers

Paper 1 Answer Key

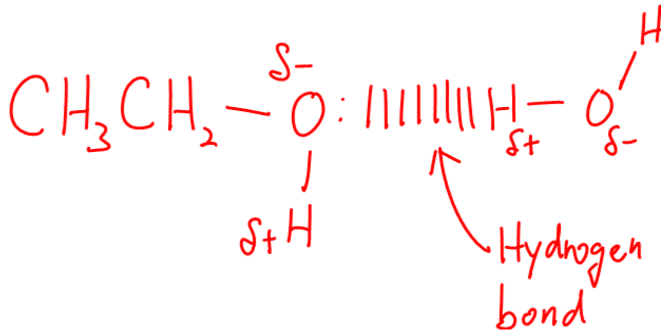
1	**B**	6	**A**	11	**A**	16	**D**	21	**A**	26	**C**
2	**C**	7	**B**	12	**B**	17	**A**	22	**D**	27	**B**
3	**D**	8	**C**	13	**C**	18	**C**	23	**D**	28	**A**
4	**D**	9	**B**	14	**A**	19	**A**	24	**C**	29	**B**
5	**C**	10	**B**	15	**B**	20	**D**	25	**D**	30	**C**

Paper 2 Section A Answers

1 **(a)** **(i)** The carbon-carbon single bond in the ethane molecule consists of 1 π bond. The carbon=carbon double bond in ethane molecule consists of 1 σ bond and 1 π bond.

A π bond is weaker than a σ bond due to less effective overlap, hence C=C bond is less than twice of C-C bond.

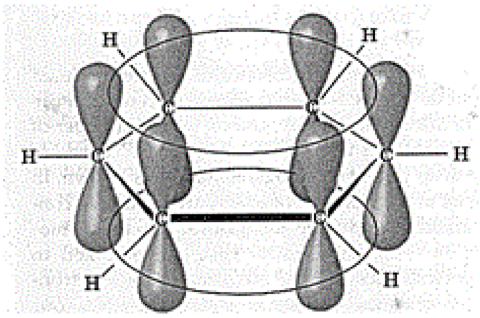
(ii)



(iii) Ethanol and butanol differs in the size of the non-polar hydrocarbon chain.

Butanol is insoluble in water even though it can form hydrogen bonds with water. Its predominantly forms dispersion forces with water due to its long, non-polar hydrocarbon chain. The energy released during formation of these dispersion forces is not enough to overcome the hydrogen bonds between water molecules and the dispersion forces between butanol.

(b) **(i)**



(ii) The delocalised π electron cloud results in stability, so the loss of this aromatic character is not energetically favored. Instead, benzene tends to undergo substitution reactions so that its π electron cloud remains intact to maintain aromatic stability.

(iii) Benzene do not undergo oxidation.

Methylbenzene is oxidized by heating with $KMnO_4$, H_2SO_4 (aq)

(c) Bond energy of C-H bond = 410 kJ mol^{-1}
Bond energy of C-Cl bond = 340 kJ mol^{-1}

As fluorine atom is smaller than chlorine, bond length of C-F bond is shorter than C-Cl bond. Therefore C-F bond is expected to be stronger than C-Cl bond, hence they do not break easily to form free fluorine atoms to attack the ozone layer.

2 (a) (i) $CrO_4^{2-} + 8H^+ + 3e \rightarrow Cr^{3+} + 4H_2O$

(ii) Amount of electrons gained by 0.0150 mole of CrO_4^{2-} = 0.0450 mol
Amount of electrons lost by 0.0225 mole of SO_2 = 0.0450 mol
Therefore each mole of SO_2 lost = (0.0450/0.0225) = 2 mol of electron

Original oxidation number of sulfur = +4
New oxidation number of sulfur = +4 + 2 = +6

(iii) SO_4^{2-}

(b) (i)

$$Kc = \frac{[Cr_2O_7^{2-}]}{[CrO_4^{2-}]^2[H^+]^2}$$

(ii) Amount of $PbCrO_4$ initiallly = 20.00/ (207.2+52.0 +16.0x4)
= 0.06188 mol
$[CrO_4^{2-}]$ initially = 0.06188/(100/1000) = 0.6188 ≈ 0.619mol dm^{-3}

(iii) $[CrO_4^{2-}]$ at equilibrium = 0.6188 / 5 = 0.1237 = 0.124 mol dm^{-3}

$$[Cr_2O_7^{2-}] \text{ at equilibrium} = \frac{0.6188 - 0.1237}{2}$$
= 0.2475 ≈ 0.248 mol dm^{-3}

(iv) Since $K_C = 7.55 \times 10^{12}$ mol^{-3} dm^9

$$[H^+] = \sqrt{\frac{[Cr_2O_7^{2-}]}{[CrO_4^{2-}]^2 \times Kc}} = \sqrt{\frac{0.2475}{0.1237^2 \times 7.55 \times 10^{12}}} = 1.463 \times 10^{-6}\ mol\ dm^{-3}$$

pH = 5.8

(v) By Le Chatelier's Principle, the system will react to <u>reduce</u> the added amount of NaOH. <u>Backward</u> reaction is favoured and position of equilibrium shifts to the <u>left</u>. [1] The solution will <u>appear yellow in color</u> due to formation of aqueous CrO_4^{2-}.

3 (a) Place a lighted splint near the mouth of the test tube. A pop sound would be heard to confirm its identity as hydrogen gas.

(b) (i) From orange to green

(ii) Oxidation

(c) (i) X: $CH_3CH_2CH_2OH$ Y: CH_3CH_2CHO

(ii) $CH_3CH_2CHO + 2Cu^{2+} + 5OH^{-} \rightarrow CH_3CH_2CO_2^{-} + Cu_2O + 3H_2O$

(iii) Test: Add Tollens' to solution and warm.
Observation: Silver mirror observed with Y. No silver mirror with X.

Test: Add 2,4-DNPH to solution and warm
Observation: orange precipitate formed with Y. No orange precipitate with X.

4 (a) Energy change when one mole of a substance is completely burnt in excess oxygen under standard conditions.

(b) (i) Carbon: $C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$
Methane: $CH_4\ (g) + 2O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (l)$

(ii) 1 MJ = 10^6 J = 1000 kJ

Since ΔH_C (C) = - 394 kJ mol^{-1}, amount of carbon need to be burned to produce 1 MJ of heat = 1000 / 394 = 2.54 mol

Since ΔH_C (CH_4) = - 890 kJ mol^{-1}, amount of methane need to be burned to produce 1 MJ of heat = 1000 / 890 = 1.12 mol

(iii) Since efficiency of coal power station = 40% , amount of carbon need to be burned to produce 1 MJ of heat = 2.538 / 0.40 = 6.35 mol

Since efficiency of natural gas power station = 51% , amount of methane need to be burned to produce 1 MJ of heat = 1.124 / 0.51 = 2.20 mol

(c) Mass of C (s) need to be burn to produce 1 MJ of electrical energy = 6.35 x 12.0 = 76.2 g
Mass of ash produced = 76.2 (5/95) = 4.01 g

(d) (i) CO_2 is a greenhouse gas that causes global warming, leading to droughts and rising sea levels.

(ii) Coal is found in the solid state, which is easier to store and transport. Hence it is easier and cheaper to operate power station that burn natural gas which is harder to store and transport.

(e) **(i)** Amount of methane need to be burned to produce 1 MJ of heat = 1.124 mol

Volume of methane at rtp = 1.124 x 24.0 = 27.0 dm^3

(ii) $CO + \frac{1}{2} O_2 \rightarrow CO_2 \quad \Delta H_C = -283$

$H_2 + \frac{1}{2} O_2 \rightarrow H_2O \quad \Delta H_C = -242$

Since 1 mole of water-gas contain ½ mole of CO and ½ mole of H_2, amount of heat energy produced by 1 mole of water-gas

= ½ (283) + ½ (242) = 262.5 kJ

Therefore amount of water-gas needed to produce 1 MJ of heat energy = 1000/262.5 = 3.810 mol

Volume of water-gas at rtp = 3.810 x 24.0 = 91.4 dm^3

(iii) - Volume of methane needed to be burn to produce 1 MJ is lower, hence it is safer and easier to operate a power station using natural gas.

Paper 2 Section B Answers

5 **(a)** $n(MnO_4^-) = 0.0200 \times 27.30 / 1000 = 5.46 \times 10^{-4}$ mol

$n(Fe^{2+})$ in 25.0 cm^3 = $5.46 \times 10^{-4} \times 5 = 2.73 \times 10^{-3}$ mol

$n(Fe^{2+})$ in 250 cm^3 = $2.73 \times 10^{-3} \times 250 / 25.0 = 2.73 \times 10^{-2}$ mol

mass of $FeCO_3$ = $2.73 \times 10^{-2} \times 115.8 = 3.161$ g

percentage by mass of $FeCO_3$ = 3.161 / 5.00 × 100% = 63.2%

(b) **(i)** $CH_3CH_2CH_2O^-$ is the least stable as the electron donating alkyl ($-CH_2CH_2CH_3$) group on the $CH_3CH_2CH_2O^-$ ion increases the electron density on the oxygen atom, making it even more negative, hence destabilising the $CH_3CH_2CH_2O^-$ ion. Thus propanol is less acidic than propanoic acid.

$CH_3CH_2COO^-$ is the most stable as the p orbital of the oxygen atom overlaps with the π electron cloud of the –C=O bond and the lone pair of electrons on the oxygen atom delocalise into the –C=O. The negative charge is dispersed over the carbon atom and the two electronegative oxygen atoms, stabilising the $CH_3CH_2COO^-$ ion. Thus propanoic acid is more acidic than propanol.

(ii) It is more difficult to remove a proton from an anion.

(iii) A buffer solution is a solution that is able to maintain a **fairly constant** pH when a **small** amount of acid or base is added.

(iv) $HO_2CCH_2CO_2Na + H^+ \rightarrow HO_2CCH_2CO_2H + Na^+$
$HO_2CCH_2CO_2Na + NaOH \rightarrow NaO_2CCH_2CO_2Na + H_2O$

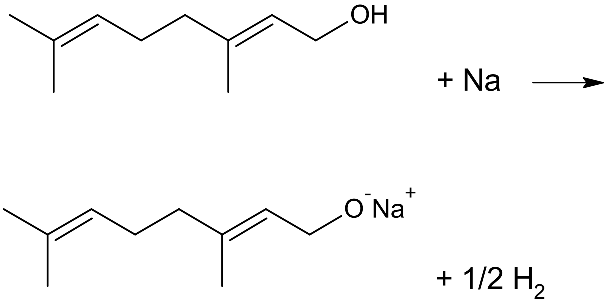
(c) **(i)** $Na_2O\ (s) + H_2O\ (l) \rightarrow 2NaOH\ (aq)$
pH = 13

$P_4O_{10}\ (s) + 6H_2O\ (l) \rightarrow 4H_3PO_4\ (aq)$
pH = 1-2

(ii) $H_3PO_4\ (aq) + 3NaOH\ (aq) \rightarrow Na_3PO_4\ (aq) + 3H_2O\ (l)$

(d) 1. Sodium metal at room temp

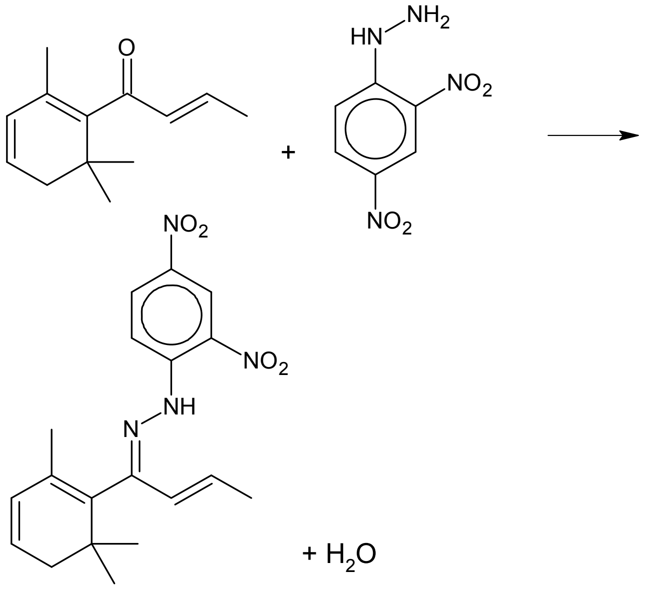
Geraniol will give effervescence. H_2 (g) evolved gives a ‘pop’ sound with a lighted splint.



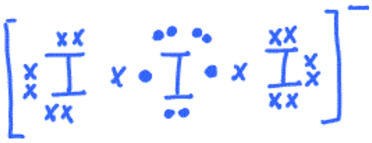
Rose oxide and damascenone will not give any effervescence. No ‘pop’ sound with a lighted splint observed.

2. 2,4-DNPH, warm

Damascenone will give an orange precipitate but not rose oxide, geraniol.



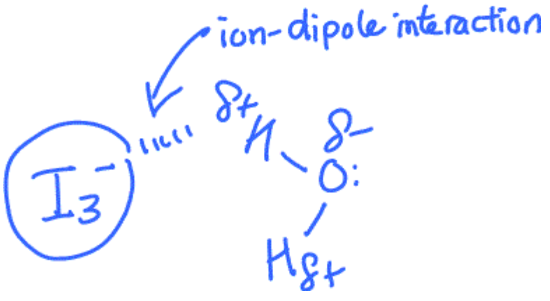
6 (a) (i)

	I_3^-	ClO_2
Dot-and-cross diagram		

I_3^- has 2 bond pairs and 3 lone pairs. The electron pairs will orientate as far as possible to minimise repulsion. Since the repulsion between lone pair – lone pair > bond pair – lone pair > bond pair – bond pair, the shape with respect to I atom is linear.

ClO_2 has 2 bond electron domains, 1 lone pair and 1 lone electron. The electron pairs will orientate as far as possible to minimise repulsion. Since the repulsion between lone pair – lone pair > bond pair – lone pair > bond pair – bond pair, the shape with respect to Cl atom is bent.

(ii)



The energy released when the H_2O molecules formed the stronger ion-dipole interaction with I_3^- ions is sufficient to overcome the hydrogen bonds between the H_2O molecules.

(iii) Both I_2 and ClO_2 have simple molecular structure with weak dispersion forces between molecules . The size of electron cloud for ClO_2 is smaller, hence less polarisable. The dispersion forces between ClO_2 molecules is weaker. Less energy is needed to overcome the weaker dispersion forces, enthalpy change of vaporisation for ClO_2 is less endothermic.

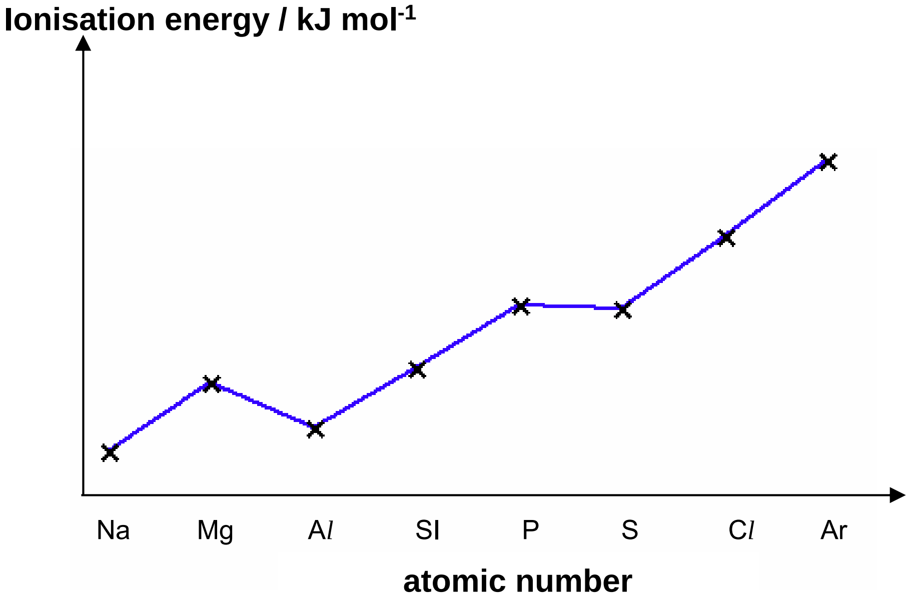
(b) **(i)** The first ionisation energy of chlorine is the energy required to remove one mole of electrons from one mole of gaseous Cl atoms to form one mole of singly charged gaseous Cl cations.

$Cl(g) \downarrow Cl^{+}(g) + e$

.

(ii) Down a group, the number of protons increases, the nuclear charge increases. As the number of electron shells increases, the shielding effect increases significantly for iodine. The increase in shielding effect outweighs the increase in nuclear charge, effective nuclear charge decreases. Less energy is needed to remove the outermost electron, hence iodine has a lower first ionisation energy.

(iii)



Between Mg (Group 2) and Al (Group 3)
Mg $1s^2 2s^2 2p^6 3s^2$
Al $1s^2 2s^2 2p^6 3s^2 3p^1$

First ionisation of Al is lower than that of Mg.
Less energy is required to remove the 3p electron in Al as it experiences increased shielding by the filled 3s subshell.

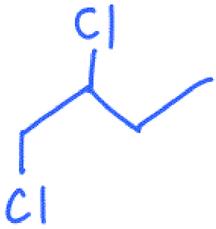
Between P (Group 15) and S (Group 16)
P $1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^1 3p_z^1$

S $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^2\ 3p_y^1\ 3p_z^1$

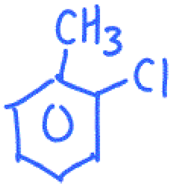
First ionisation of S is lower than that of P.
Less energy is required to remove the paired $3p_x$ electron in S as it experiences interelectronic repulsion arising from 2 electrons occupying the same 3p orbitals.

(c) (i)

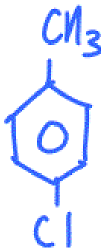
(ii)



(iii)



OR



7 **(a)** **(i)** $MgCl_2$ undergoes hydration with water to from aqueous Mg^{2+} and Cl^- ions.
$[Mg(H_2O)_6]^{2+}$ then undergoes slight hydrolysis with water to produce H_3O^+ hence a weakly acidic solution is formed. pH = 6.5
$MgCl_2\ (s) + 6H_2O(l) \rightarrow [Mg(H_2O)_6]^{2+}(aq) + 2Cl^-(aq)$
$[Mg(H_2O)_6]^{2+}\ (aq) + H_2O(l) \rightleftharpoons [Mg(H_2O)_5OH]^+\ (aq) + H_3O^+$

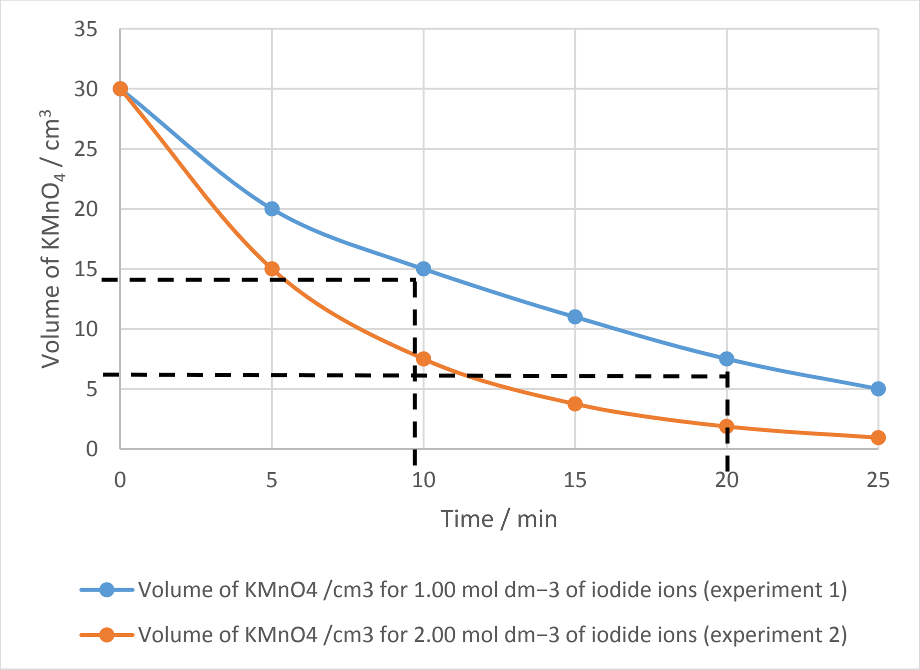
Both $SiCl_4$ and PCl_3 (or PCl_5) undergoes hydrolysis with water to from a strongly acidic solution, pH = 1 – 2.

$SiCl_4\ (l) + 2\ H_2O\ (l) \rightarrow SiO_2\ (s) + 4\ HCl\ (aq)$
$PCl_3\ (l) + 3\ H_2O\ (l) \rightarrow H_3PO_3\ (aq) + 3\ HCl\ (aq)$
OR $PCl_5\ (l) + 4\ H_2O\ (l) \rightarrow H_3PO_4\ (aq) + 5\ HCl\ (aq)$

(ii) $MgCl_2$ is an ionic chloride hence it undergoes hydration to form the ions readily while both $SiCl_4$ and PCl_3 (or PCl_5) are covalent chlorides which undergoes hydrolysis with water.

(b) **(i)** 50 cm^3 of cold water was added prior to the titration to stop/slow down the reaction so as to achieve a more accurate titre value at that time / to find the concentration at that instance.

(ii)



(iii) When volume of $KMnO_4$ decreases from 30 cm^3 to 15 cm^3, time taken is 10 min.
When volume of $KMnO_4$ decreases from 15 cm^3 to 7.5 cm^3, time taken is 10 min.
Since the 2 half lives are approximately constant at 10 min, reaction is first order to $KMnO_4$.

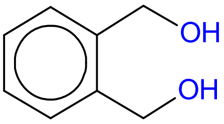
Since volume of H_2O_2 and concentration of $KMnO_4$ are constant, $[H_2O_2]$ is proportional to $V(KMnO_4)$. Reaction is thus first order with respect to H_2O_2.
When $[I^-] = 1.00$ mol dm^{-3}, initial rate = 30/6.5 = 4.62 cm^3 min^{-1}
When $[I^-] = 2.00$ mol dm^{-3}, initial rate = 30/11.5 = 2.61 cm^3 min^{-1}

As $[I^-]$ doubles (2/1), initial rate also doubles (4.62/2.61 ≈ 2), hence order of reaction with respect to I^- is one.

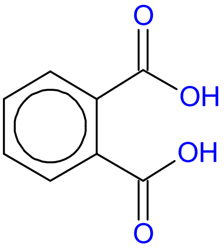
Rate = $k[H_2O_2][I^-]$
Units for rate constant: mol^{-1} dm^3 min^{-1}

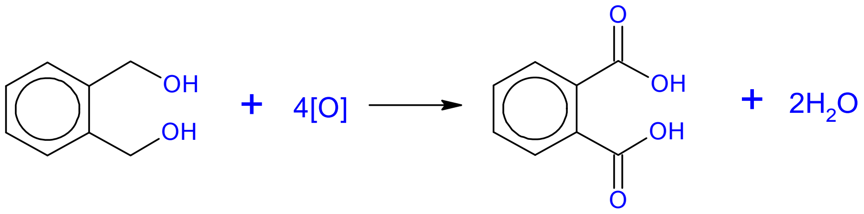
(c) **(i)** The primary alcohol in A undergoes oxidation with acidified KMnO4 to form carboxylic acid in B.

A:



B:





(ii) Type of reaction: Condensation
Reagents & conditions: $CH(CH_3)_2OH$, conc. H_2SO_4, heat under reflux

(iii) Reagent and condition: I_2(aq), NaOH(aq), warm
Observations for **C**: Yellow ppt of CHI_3 formed.
Observations for **D**: No yellow ppt of CHI_3 formed.