

# Yishun Junior College H1 Chemistry Preliminary Examinations 2015

## Paper 1 Answers

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

(A): 7

(B): 8

(C): 9

(D): 6

## Paper 2 Answers

- 1 (a) Nitrogen has lesser nuclear charge / lesser number of protons and lesser shielding effect/lesser number of electron shells than phosphorus. [1]

As the increase in shielding effect outweighs the increase in nuclear charge, the attraction between the nucleus and valence electrons is stronger for nitrogen. [1]

Hence, more energy is needed to remove the first electron from nitrogen.

[2]

- (b) Both ammonia and phosgene have simple molecular structure.

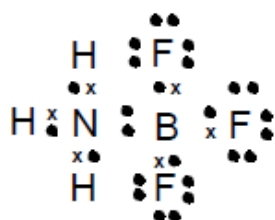
Lesser energy is needed to overcome the weaker intermolecular permanent dipole-permanent dipole attractions [1] in phosgene compared to the strong intermolecular hydrogen bonds [1] in ammonia.

[2]

- (c) (i) A dative bond is formed when a shared pair of electrons between two atoms is contributed by only one of the atoms.

[1]

(ii)



Dative bond ( $e^-$  pair from N atom donated to B atom) – [1]  
Correct dot-and-cross diagram – [1]

[2]

- (iii) N in ammonia has 3 bond pairs and 1 lone pair of electrons while N in  $\text{H}_3\text{NBF}_3$  has 4 bond pairs and no lone pairs of electrons. [1]

Lone pair-bond pair repulsion is greater than bond pair-bond pair repulsion.

OR Lone pair of electrons repel more than bond pairs. [1]

Hence, the H-N-H bond angle is larger in  $\text{H}_3\text{NBF}_3$ .

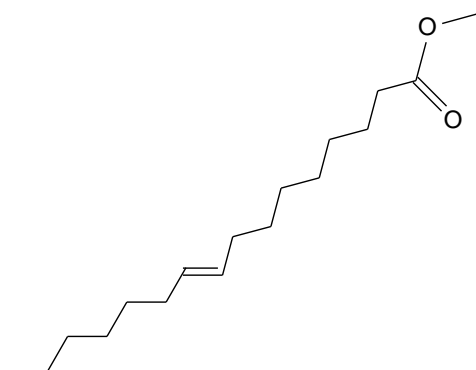
[2]

[Total:9]

- 2 (a) alkene [1] and ester [1]

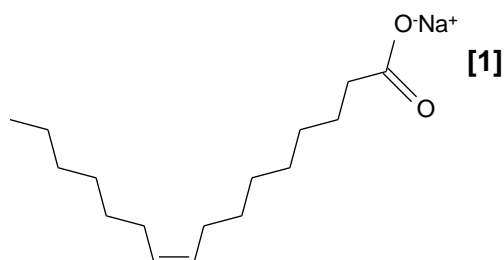
[2]

(b)



[1]

(c)



[1]

$\text{CH}_3\text{OH}$  [1]

[2]

- (d) (i) The standard enthalpy change of combustion of a substance is the heat evolved when one mole of the substance is completely burnt in oxygen gas at 25°C and 1 atm.

[1]

- (ii) heat released =  $100 \times 4.18 \times (56.5 - 25) = 13200 \text{ J}$

[1]

- (iii)  $\eta_A = \frac{2.50}{268} = 9.33 \times 10^{-3} \text{ mol}$

[1]

- (iv)  $\Delta H_c = -\frac{13.2}{9.33 \times 10^{-3}} = -1420 \text{ kJmol}^{-1}$

working – [1]

sign + units – [1]

[2]

[Total:10]

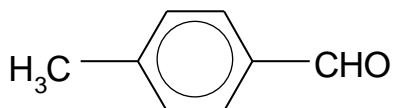
- 3 (a) **Test 1:** Compound **C** is a carbonyl compound OR a ketone or aldehyde [1]

**Test 2:** Compound **C** is an aldehyde or benzaldehyde [1]

**Test 3:** Compound **C** is not an aliphatic aldehyde OR Compound **C** is a benzaldehyde [1]

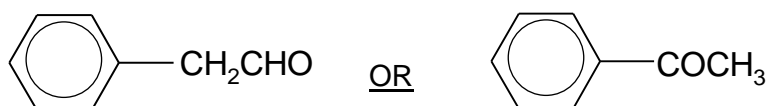
[3]

(b)



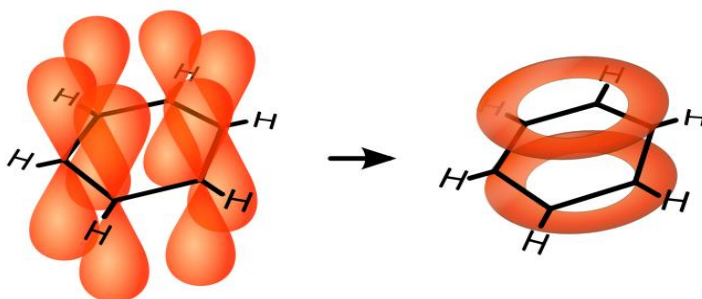
[1]

(c)



[1]

(d)



Each carbon atom has 3 sp<sup>2</sup> hybrid orbitals and 1 unhybridised p-orbital. [1]

1 sp<sup>2</sup> orbital overlap head-on with the s orbital of H atom to form a C-H single (sigma bonding). The other 2 sp<sup>2</sup> orbitals are used to form sigma bonds with the neighbouring carbon atoms (C-C single bonds). [1]

The unhybridised p-orbitals for the 6 carbon atoms overlap sideways to form delocalised electron clouds above and below the plane of the carbon ring. OR draw a suitable diagram (as shown above) [1]

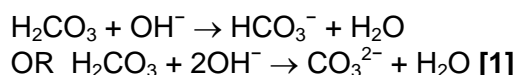
[3]

[Total: 8]

- 4 (a) **oxidation:**  $\text{MnO}_2 + 4\text{OH}^- \rightarrow \text{MnO}_4^{2-} + 2\text{H}_2\text{O} + 2\text{e}^-$  [1]  
**reduction:**  $\text{ClO}_3^- + 3\text{H}_2\text{O} + 6\text{e}^- \rightarrow \text{Cl}^- + 6\text{OH}^-$  [1]  
**overall:**  $3\text{MnO}_2 + \text{ClO}_3^- + 6\text{OH}^- \rightarrow 3\text{MnO}_4^{2-} + \text{Cl}^- + 3\text{H}_2\text{O}$  [1]

[3]

- (b) Carbon dioxide reacts with water to form carbonic acid.  
OR  $\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$  [1]



Carbonic acid react with the hydroxide ions. By Le Chatelier's principle, the equilibrium position (step 2) shifts to the right so as to replenish the hydroxide ions. Hence, the percentage of  $\text{MnO}_4^-$  increases. [1]

[3]

- (c) (i) Manganese undergoes reduction as its oxidation number decreases from +6 in  $\text{MnO}_4^{2-}$  to +4 in  $\text{MnO}_2$  while sulfur undergoes oxidation as its oxidation number increases from +4 in  $\text{SO}_3^{2-}$  to +6 in  $\text{SO}_4^{2-}$ .

Definition of redox – [1]  
 Oxidation numbers – [1]

[2]

(ii)  $\eta_{\text{KMnO}_4} = 0.02 \times \frac{26.80}{1000} = 5.36 \times 10^{-4} \text{ mol}$

[1]

(iii)  $\eta_{\text{SO}_3^{2-}} \text{ in } 25\text{cm}^3 = \frac{5}{2} \times 5.36 \times 10^{-4} = 1.34 \times 10^{-3} \text{ mol}$  [1]  
 $\eta_{\text{SO}_3^{2-}} \text{ in } 250\text{cm}^3 = 10 \times 1.34 \times 10^{-3} = 0.0134 \text{ mol}$  [1]  
 Mass of pure  $\text{Na}_2\text{SO}_3 = 0.0134 \times 126.1 = 1.69 \text{ g}$  [1]  
 $\% \text{ purity} = \frac{1.69}{2.00} \times 100 = 84.5\%$  [1]

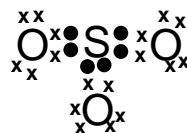
[4]

[Total:13]

5 (a)



sulfur dioxide [1]



sulfur trioxide [1]

There are 2 bond pairs and 1 lone pair of electrons around the S atom in  $\text{SO}_2$  while there are 3 bond pairs and no lone pairs of electrons around the S atom in  $\text{SO}_3$ .

AND To minimise repulsion between the electrons, the electron pairs arrange themselves in a trigonal planar fashion. [1]

Shape of  $\text{SO}_2$  – bent OR v-shaped  
AND Shape of  $\text{SO}_3$  – trigonal planar [1]

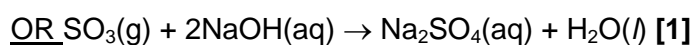
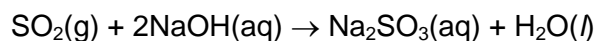
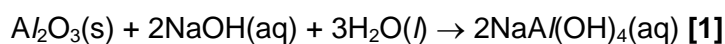
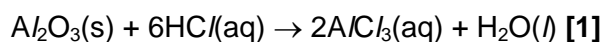
[4]

- (b)  $\text{Al}_2\text{O}_3$  is ionic with significant covalent character and hence is amphoteric in nature.

$\text{Al}_2\text{O}_3$  can react with both acids and alkalis.

Oxides of S are covalent and hence are acidic in nature.

Oxides of S react with alkalis to form a salt and water. [1]



[4]

(c) (i)  $K_c = \frac{[SO_3]^2}{[SO_2]^2[O_2]} \quad [1]$

units:  $\text{mol}^{-1}\text{dm}^3 \quad [1]$

[2]

(ii)

	$2SO_2$	$O_2$	$2SO_3$
Initial amt/mol	5	2	0
Change in amt/mol	-3	-1.5	+3
Eqm amt/mol	2	0.5	3
Eqm conc/mol	1	0.25	1.5

[1]

$$K_c = \frac{(1.5)^2}{(1)^2(0.25)} = 9.00 \text{ mol}^{-1}\text{dm}^3 \quad [1]$$

[2]

(iii) By LeChatelier's Principle, the position of equilibrium will shift to the left. [1]

The endothermic backward reaction is favoured so as to absorb the heat added, producing more  $SO_2$  and  $O_2$ . [1]

[2]

(d) (i) A strong Bronsted acid is a proton donor [1] which undergoes complete dissociation [1] in water.

[2]

(ii)  $[H^+] = 10^{-1.2} = 0.0631 \text{ mol dm}^{-3} \quad [1]$

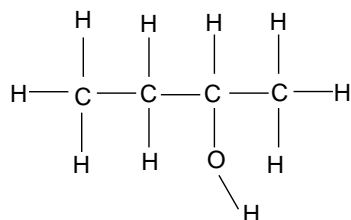
$[H_2SO_4] = 0.0631 \div 2 = 0.0315 \text{ mol dm}^{-3} \quad [1]$

[2]

(e) (i) addition

[1]

(ii)



[1]

[Total:20]

- 6 (a) Product 1: Ethanoic acid  
 Reagents & Conditions:  $\text{KMnO}_4$ , dil.  $\text{H}_2\text{SO}_4$ , heat under reflux  
 Observations: Purple  $\text{KMnO}_4$  is decolourised.  
 Equation:  $\text{CH}_3\text{CH}_2\text{OH} + 2[\text{O}] \rightarrow \text{CH}_3\text{COOH} + \text{H}_2\text{O}$

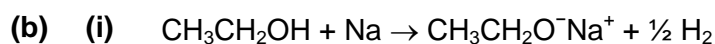
Product 2: Ethanal  
 Reagents & Conditions:  $\text{K}_2\text{Cr}_2\text{O}_7$ , dil.  $\text{H}_2\text{SO}_4$ , immediate distillation  
 Observations: Orange acidified  $\text{K}_2\text{Cr}_2\text{O}_7$  turns green  
 Equation:  $\text{CH}_3\text{CH}_2\text{OH} + [\text{O}] \rightarrow \text{CH}_3\text{CHO} + \text{H}_2\text{O}$

Identify both products – [1]

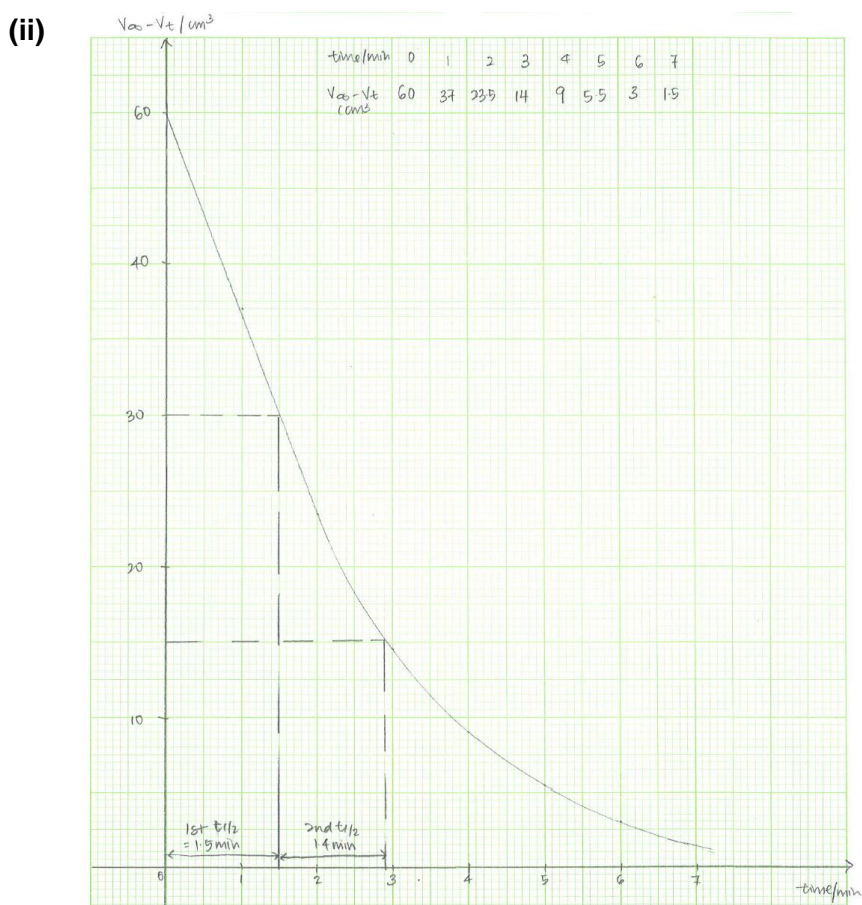
Reagents & Conditions + Observations for each product – [1] x 2

Each equation – [1] x 2

[5]



[1]



Plot volume of gas against time

Or Plot  $(V_{\infty} - V_t)$  against time with labelled axes [1]

All points plotted correctly [1]

Best-fit curve [1]

Show at least 2 half-lives on graph + half-life  $\approx 1.5$  min + constant half-lives [1]

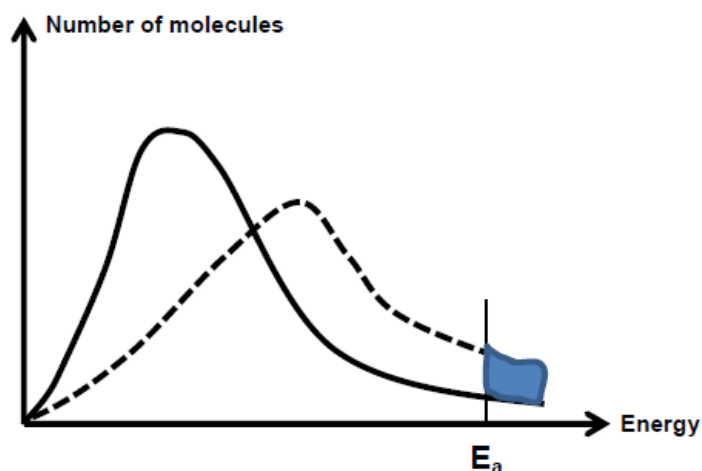
[4]

(iii) Ethanol is in large excess and so the change in the concentration of ethanol in the experiment is negligible. [1]

(iv)  $\eta_{Na} = 2 \times \eta_{H_2} = 2 \times \frac{60}{24000} = 0.00500 \text{ mol}$  [1]  
 $\text{Mass of Na} = 0.005 \times 23 = 0.115 \text{ g}$  [2]

(v) Sodium is readily oxidised in air to form sodium oxide. [1]  
 $\text{Na} + \frac{1}{2} \text{O}_2 \rightarrow \text{Na}_2\text{O}$  [1] [2]

(vi)



(Correct diagram – [1] )

When temperature increases, the average kinetic energy of the reacting particles is increased. [1]

Hence, the proportion of particles with energy equal to or greater than the activation energy increases significantly as seen in the shaded area in the diagram. [1]

In addition, when the temperature of the reactants is increased, their average speeds increase and so, the frequency of collisions between reacting particles increases. This increases the number of effective collisions and consequently the rate of reaction. [1] [3]

(4 marking points; maximum 3 marks)

(c) Reagents & conditions: aq  $\text{I}_2$ , aq NaOH, warm [1]  
 Observations: A yellow precipitate will be formed for ethanol while no precipitate will be formed for propanol. [1] [2]

Total: 20

- 7 (a) (i) Trend: The anions ( $P^{3-}$  to  $Cl^-$ ) are bigger than the cations ( $Na^+$  to  $Si^{4+}$ ) within the same Period.

Anions have one additional shell of electrons than cations. Hence, the distance between the valence electrons and the nucleus is greater. The valence electrons also experience higher shielding effect from the nucleus by the additional inner shell of electrons. The valence electrons are less strongly attracted by the nucleus. [1]

Trend: The ionic radius of  $Na^+$  to  $Si^{4+}$  decreases with increasing proton number. Similarly, the ionic radius of  $P^{3-}$  to  $Cl^-$  also decreases with increasing proton number.

$Na^+$ ,  $Mg^{2+}$ ,  $Al^{3+}$  and  $Si^{4+}$  ions are isoelectronic ( $1s^2 2s^2 2p^6$ ). Similarly,  $P^{3-}$ ,  $S^{2-}$  and  $Cl^-$  ions are isoelectronic ( $1s^2 2s^2 2p^6 3s^2 3p^6$ ). The same number of valence electrons becomes more strongly attracted to the nucleus as a result of increasing nuclear charge. [1]

[3]

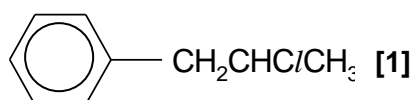
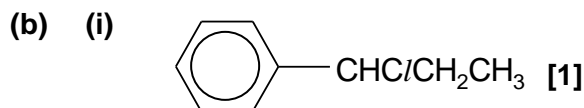
Both trends – [1]

- (ii) Na, Mg and Al have high melting points.  
Na, Mg and Al have giant metallic structure. A large amount of energy is required to overcome the strong electrostatic forces between the metallic ions and the 'sea' of delocalised electrons. [1]

Si has a very high melting point.  
Si has a giant covalent structure. A large amount of energy is required to break the strong covalent bonds between the Si atoms throughout the entire structure. [1]

$P_4$ ,  $S_8$ ,  $Cl_2$  and argon have low melting points.  
These elements have simple molecular structures. A small amount of energy is required to overcome the weak intermolecular instantaneous dipole-induced dipole interactions. [1]

[3]



[2]

- (ii) type of reaction: substitution [1]  
conditions: UV light, limited  $Cl_2$  [1]

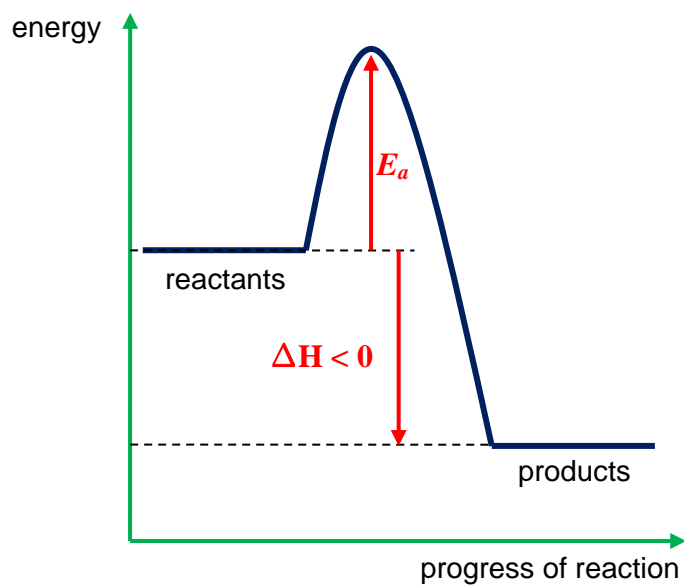
[2]

- (iii)  $\Delta H_{rxn} = [BE(C-H) + BE(Cl-Cl)] - [BE(C-Cl) + BE(H-Cl)]$   
 $= (410 + 244) - (340 + 431) = -117 \text{ kJmol}^{-1}$  [1]  
correct bond energy values – [1]

[2]



(iv)

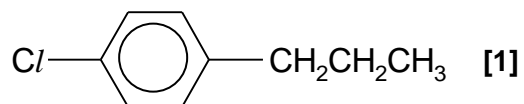
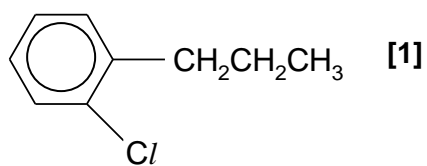


shape of graph with correct axes – [1]

label  $E_a$  and  $\Delta H$  – [1]

[2]

(v) conditions: anhydrous  $\text{AlCl}_3$  OR  $\text{FeCl}_3$  OR Fe catalyst [1]



[3]

- (c) Halogenoalkanes undergo substitution and the halide ion formed gives a precipitate with aqueous silver nitrate. [1]

The rate of reaction is inversely proportional to the strength of the C-X bond. The bond strength decreases in the order C-Cl > C-Br > C-I as seen from their bond energies. [1]

$$\text{BE (C-Cl)} = 340 \text{ kJ mol}^{-1}$$

$$\text{BE(C-Br)} = 280 \text{ kJ mol}^{-1}$$

$$\text{BE(C-I)} = 240 \text{ kJ mol}^{-1}$$

Hence, the rate of reaction increase in the order: 1-iodopropane > 1-bromopropane > 1-chloropropane

In chlorobenzene, the p orbital of the chlorine atom overlaps with the  $\pi$  orbitals of the benzene ring and forming a partial double bond character which strengthens the C-Cl bond, making it difficult to cleave. Hence, chlorobenzene does not give a precipitate. [1]

[3]

Total:20