## Suggested Answers for 2025 Y6 H1 Chemistry Preliminary Examination

### Paper 1:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | B | B | D | D | D | C | C | C | C | D | C | C | B | C | B | C | A | A | C |

| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|
| B | B | C | B | C | D | A | B | C | C |

### Worked solutions for Paper 1

**Q1**

| | no. of protons | no. of neutrons | no. of electrons |
|---|---|---|---|
| $^{32}S^{2-}$ | 16 | 16 | 18 |
| $^{34}S$ | 16 | 18 | 16 |

Ans: **A**

**Q2**

Electronic configuration: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

| | | |
|---|---|---|
| ✓ | 1 | The third shell has no unpaired electrons. |
| | 2 | The valence electronic configuration of an isolated atom is $3s^2\ 3p^6$. |
| | 3 | The 2p orbitals have the same energy (degenerate) and same shape (dumbbell). |

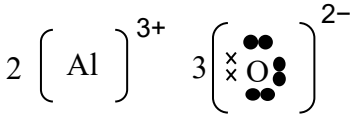
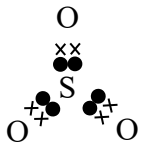
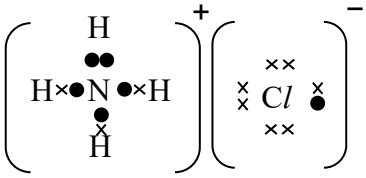
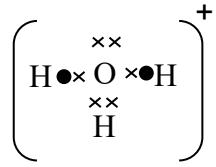
Ans: **B (1 only)**

**Q3**

| | | | electronic configuration |
|---|---|---|---|
| | **A** | $Ti^{2+}$ | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2$ |
| ✓ | **B** | $Zn^{2+}$ | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$ |
| | **C** | $Cu^{2+}$ | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$ |
| | **D** | $Fe^{2+}$ | $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$ |

Ans: **B**

**Q4**

| | | species | bonding |
|---|---|---|---|
| | **A** | $Al_2O_3$ |  ionic |
| | **B** | $SO_3$ |  covalent only |
| | **C** | $NH_4Cl$ |  ionic, covalent and dative |
| ✓ | **D** | $H_3O^+$ |  covalent and dative |

Ans: **D**

**Q5**

The reaction involves the cleavage of the C−X bond. The weaker the C−X bond, the easier it can be broken and the faster is the rate of reaction.

| | | |
|---|---|---|
| | 1 | While permanent dipole-permanent dipole forces between chloroethane molecules are stronger than those between bromoethane molecules, it does not contribute to the ease of breaking the C−X bond. |

| | | |
|---|---|---|
| | 2 | Though C−C*l* bond is more polar than C−Br bond, it does not increase the reactivity as the rate of reaction is observed to be more rapid with bromoethane than chloroethane. |
| ✓ | 3 | Since C−C*l* bond is stronger than C−Br bond, more energy is required to break the C−C*l* bond, this leads to a slower rate of reaction in chloroethane. |

Ans: **D (3 only)**

**Q6**

Liquefaction of gases can be achieved by:

- increasing pressure on a gas to bring the gas molecules closer together so that the strength of the intermolecular forces becomes more significant.
- decreasing temperature so that sufficient energy is removed for the gas molecules to move at a slower speed and to make the gas change from the gaseous to the liquid state.

The ease of liquefaction of gases generally depends on the strength of intermolecular forces. The stronger the intermolecular forces between the gas molecules, the easier it will be to liquefy a gas.

Ans: **D**

**Q7**

| | physical state room temperature | conductivity | solubility in water |
|---|---|---|---|
| ionic | solid | non-conductors in solids, conductors in molten / aq | usually soluble in polar solvents, insoluble in non–polar solvents |
| metallic | solid, except for Hg | conductors in solids / liquids | insoluble in polar and non–polar solvents |
| giant molecular | solid | non-conductors, except graphite | insoluble in all solvents. |
| simple molecular | mostly gases/ volatile liquids | non-conductors when solid, liquid and usually in aq solutions. A few (e.g.HC*l*) ionise in water so that they conduct electricity in aq solutions. | many are insoluble in polar solvents, soluble in non–polar solvents |

Ans: **C**

**Q8**

Steps to take:

1. convert mg to g (divide mg by 1000)
2. divide by $M_r$ (divide by 71) to get amount (no. of moles) of C$l_2$ molecules
3. multiply the amount by Avogadro's constant to obtain number of C$l_2$ molecules ($\times 6 \times 10^{23}$)

Since density is 0.005 mg dm$^{-3}$

In 1 dm$^3$, the mass of C$l_2$ in air = 0.005g

Hence: $\frac{0.005}{1000} \times \frac{1}{71} \times 6 \times 10^{23}$

Ans: **C**

**Q9**

$C_xH_y(g) + (x + y/4)O_2(g) \longrightarrow xCO_2(g) + (y/2)H_2O(l)$

Amt of $O_2$ used = 0.720/24 = 0.03 mol
Amt of $H_2O$ produced = 0.36/18.0 = 0.02 mol

Taking mole ratio:

Q : water = 1 : y/2 = 0.0050 : 0.02 $\Rightarrow$ y = 8

$O_2$ : Q = x + 8/4 : 1 = 0.03 : 0.0050 $\Rightarrow$ x = 4

$\therefore$ Q is $C_4H_8$.

Ans: **C**

**Q10**

Heat released = (100)(4.18)(15.0)
= 6270 J

Amt of Mg = $\frac{1.0}{24.3}$
= 0.0411 mol

Amt of HCl = 100/1000 x 1 = 0.1

Since 1 mole of Mg reacts with 2 moles of HC*l*, Mg is limiting.

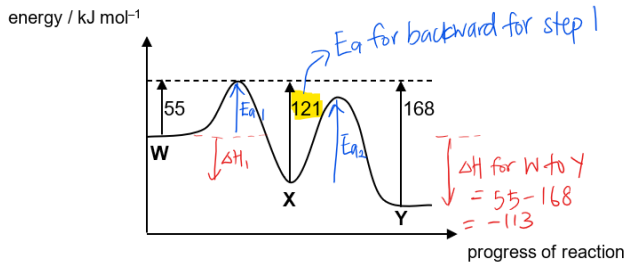
No. of moles of $H_2$ formed = no. of moles of Mg reacted = 0.0411

Heat released = $-\frac{6270}{0.041152}$
= − 152361 J mol$^{-1}$

= − 152 kJ mol$^{-1}$

Ans: **C**

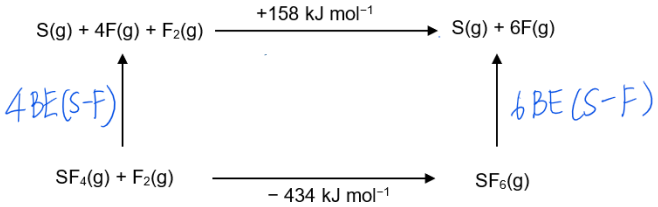
**Q11**




| | | |
|---|---|---|
| | **A** | The activation energy for the forward reaction of step 1 is **lower** than that of step 2. |
| | **B** | Step 2 is **less** exothermic than step 1. |
| | **C** | The activation energy for the backward reaction of step 1 is **+121** kJ mol$^{-1}$. |
| ✓ | **D** | The enthalpy change of reaction for the conversion of W to Y is 55-168 = −113 kJ mol$^{-1}$. |

Ans: **D**

**Q12**




By Hess' Law,
4BE(S-F) + 158 = -434 + 6BE(S-F)
BE (S-F) = 296 kJ mol$^{-1}$

Ans:**C**

**Q13**

$\Delta H_r = \Sigma n\Delta H_f(\text{products}) - \Sigma m\Delta H_f(\text{reactants})$
$\Delta H_r = 6(-394) + 6(-286) - (-1273)$
$= -2807$ kJ mol$^{-1}$

Ans: **C**

**Q14**

100 μg cm$^{-3}$ $\xrightarrow{t_{½}}$ 50 μg cm$^{-3}$ $\xrightarrow{t_{½}}$ 25 μg cm$^{-3}$
(after 4 hours)

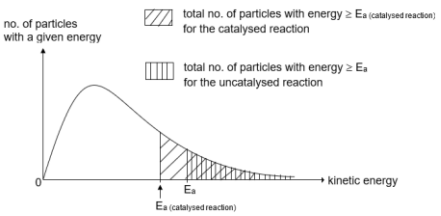
$t_{½}$ = 2 hours

200 μg cm$^{-3}$ $\xrightarrow{t_{½}}$ 100 μg cm$^{-3}$ $\xrightarrow{t_{½}}$ 50 μg cm$^{-3}$ $\xrightarrow{t_{½}}$ 25 μg cm$^{-3}$

3 x $t_{½}$ = 6 hours

Ans: **B**

**Q15**

| | | |
|---|---|---|
| | **A** | Rate constant is increased by<br>• increase in temperature<br>• lowering of activation energy |
| | **B** | A catalyst is a substance which increases the rate of a reaction by providing an alternative pathway with lower activation energy without itself undergoing any permanent chemical change. |
| ✓ | **C** | The kinetic energy of the molecules is affected by the temperature, not catalyst. Hence the introduction of catalyst does not make the particles move more quickly. |
| | **D** |  <br>Since more particles have E greater or equal to Ea, the frequency of successful collision increases |

Ans: **C**

**Q16**

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -92$ kJ mol$^{-1}$

Statement 1 incorrect: a catalyst increases rate of reaction but does not affect the yield

Statement 2 incorrect: a higher pressure favours the side with *fewer* (not greater) number of molecules

Statement 3 correct: an increase in temperature always leads to increased rate

Statement 4 incorrect: Haber process is exothermic. Applying Le Chatelier's principle, a *lower* temperature (not higher) will give greater yield of ammonia.

Ans: **B (3 only)**

**Q17**

Given that the volume of the flask is 1 dm$^3$,

| | $N_2O_4(g)$ | $\rightleftharpoons$ | $2NO_2(g)$ |
|---|---|---|---|
| Initial conc/ mol dm$^{-3}$ | 0 | | 4/1 = 4 |
| Change in conc. / mol dm$^{-3}$ | +x | | 4 – 2x |
| Eqm conc. / mol dm$^{-3}$ (Since x = 1.0) | 1.0 | | 4 – 2(1.0) = 2.0 |

$K_c = [NO_2]^2 / [N_2O_4] = 2.0^2 / 1.0 = 4.0$

Incorrect answers:
- Reverse K expression, resulting in incorrect K = $1.0/2.0^2 = 0.25$

- Failed to square the numerator, resulting in incorrect K = 2.0/1.0 = 2.00
- Failed to −2x for $NO_2$, resulting in eqm amount of $NO_2$ = 3.0, incorrect K = $3.0^2/1.0$ = 9.00

Ans: **C**

**Q18**

Dynamic equilibrium refers to a state in a reversible system in which the forward and backward reactions are continuing at the same rate, resulting in no net change in the macroscopic properties of the reactants and products.

Ans: **A**

**Q19**

| | | |
|---|---|---|
| ✓ | **A** | $[H^+] = 10^{-pH}$<br>$= 10^{-4.0}$<br>$= 1 \times 10^{-4}$ mol dm$^{-3}$<br><br>Since [HX] > [H$^+$], HX undergoes partial dissociation. Hence it is a weak acid. |
| | **B** | $K_a = \frac{[H^+][A^-]}{[HA]}$<br>$= \frac{(10^{-4.0})^2}{0.100}$<br>$=1 \times 10^{-7}$ |
| | **C** | $[H^+] = 10^{-pH}$<br>$= 10^{-4.0}$<br>$=1 \times 10^{-4}$ mol dm$^{-3}$ |
| | **D** | When 25.0 cm$^3$ of 0.100 mol dm$^{-3}$ NaOH(aq) is added to the solution, HX is completely neutralised to give salt and water. |

Ans: **A**

**Q20**

Recall the following definitions

| | |
|---|---|
| Arrhenius acid | hydrogen-containing substance that releases hydrogen ions |
| Arrhenius base | hydroxide-containing substance that releases hydroxide ions |
| Brønsted-Lowry Acid | proton donor |
| Brønsted-Lowry Base | proton acceptor |

Ans: **C**

**Q21**

Statement 1 incorrect: electronegative of X *decreases* down the group, so the bonding pair of electrons gets *further away* (not closer) from the X nucleus down the group

Statement 2 and 3 are correct: X increase in size down the group, H-X bond length increases, H-X bond strength decreases, and hence thermal stability decreases down the group.

Ans: **B (2 and 3 only)**

**Q22**

One is a white powder which forms a colourless, slightly acidic solution on dissolving in water.

- Substance is $MgCl_2$
- $Mg^{2+}$(aq) solution is colourless and undergoes slight hydrolysis to give slightly acidic solution
- $[Mg(H_2O)_6]^{2+}(aq) + H_2O(l) \rightleftharpoons [Mg(H_2O)_5(OH)]^+(aq) + H_3O^+(aq)$

The other is a colourless liquid which, on mixing with water, fumes (due to HC*l*) and leaves an acidic solution with a pH less than 3

- Substance is $PCl_5$
- $PCl_5(l) + 4H_2O(l) \longrightarrow H_3PO_4(aq) + 5HCl(aq)$

Ans: **B**

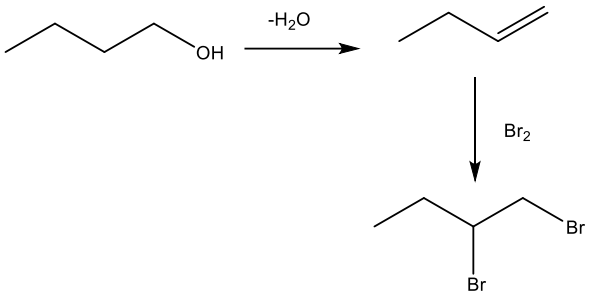
**Q23**

| | | |
|---|---|---|
| | **A** | Only Xe (noble gas) exists as atoms. |
| | **B** | Te is a semi-conductor (like Si), so it does not exist as a giant metallic structure. |
| ✓ | **C** | The elements with metallic structures in Period 5 are the ones with high electrical conductivity, namely Rb, Sr, In, Sn and Sb. The only one in Period 3 are Na, Mg and Al. |
| | **D** | Rb is a metal.<br>Xe exists as atoms.<br>Only iodine exists as simple molecules of $I_2$. |

Ans: **C**

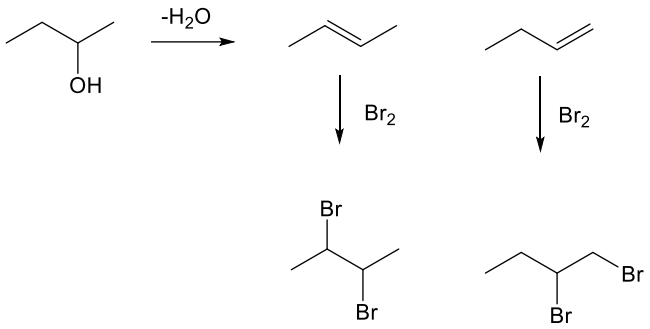
**Q24**

Option A:



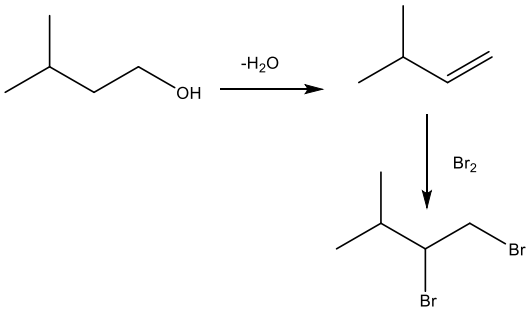

Only 1 dibromo product

Option B:



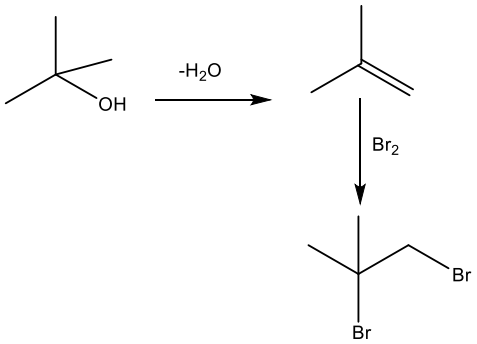

2 structural isomers of dibromo compounds

Option C:




Only 1 dibromo product

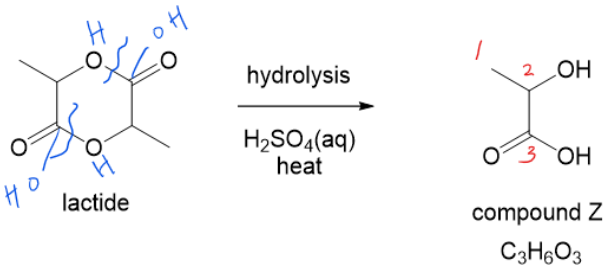
Option D:




Only 1 dibromo product

Ans: **B**

**Q25**




Statement 1 correct. Z is 2-hydroxypropanioic acid.

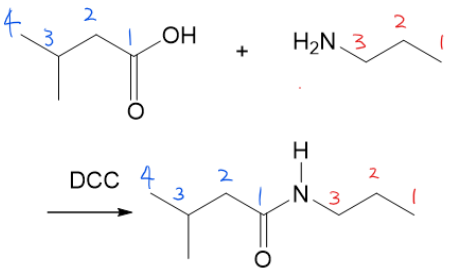
Statement 2 incorrect. No carbonyl group (aldehyde or ketone) in Z, hence no reduction by $NaBH_4$.

Statement 3 incorrect. No C=C, hence no decolourisation of $Br_2$ in $CCl_4$.

Statement 4 correct. There is a secondary alcohol in Z which can undergo oxidation with acidified $KMnO_4(aq)$.

Ans: **C (1 and 4 only)**

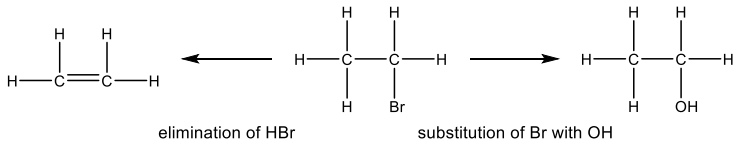
**Q26**




Check that the reactants carboxylic acid and amine are structurally consistent with product J, i.e. check number of C and branching of the hydrocarbon chain.

Ans: **D**

**Q27**




Ans: **A**

**Q28**

Option 1 correct: decrease in branching about the chain leads to increase in density due to better packing of the chains

Option 2 correct: increase in hydrogen bonding between chains leads to increase in strength as the attraction between chains increases

Option 3 incorrect: increase cross-linking between chains leads to decrease (not increase) in flexibility

Ans: **B**

**Q29**

Monomer is $CF_2=CF_2$
$M_r$ of monomer = $12 \times 2 + 19 \times 4 = 100$

Number of monomers to make Teflon
= 200 000 / 100 = 2000 monomers

Ans: **C**

**Q30**

| | | |
|---|---|---|
| | **A** | High tensile strength as each carbon atom is attached to 3 others by a network of strong covalent bonds within the graphene layer. |
| | **B** | Graphene conducts electricity because one p electron per carbon atom is delocalised over the whole graphene layer. |
| ✓ | **C** | Graphene is strong because the carbon atoms form a network of covalent bonds. |
| | **D** | Graphene is a single layer of carbon atoms arranged in a hexagonal lattice and does not have a layered structure. |

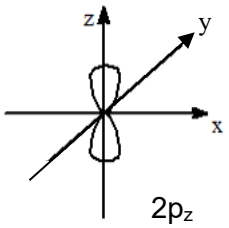
Ans: **C**

## Paper 2 Section A

**1(a)(i)**

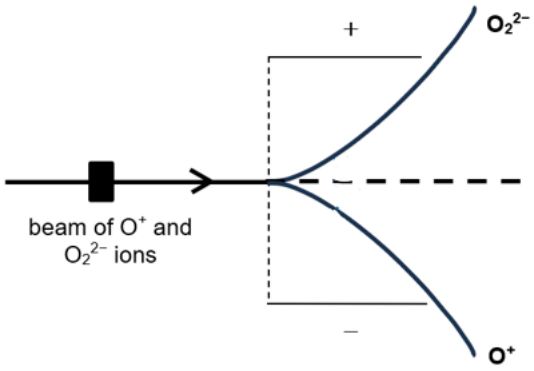
| species | number of protons | number of neutrons | number of electrons | electronic configuration |
|---|---|---|---|---|
| $^{16}_{8}O^{+}$ | 8 | 8 | | $1s^2 2s^2 2p^3$ |
| $^{16}_{8}O_2^{2-}$ | 16 | | 18 | |

**1(a)(ii)**




Any of the 2p orbital

**1(b)**

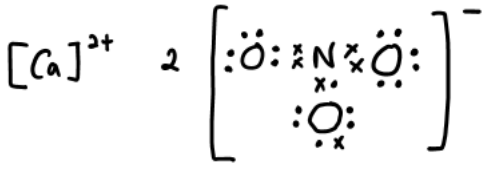



Angle of deflection for $O_2^{2-}$ is equal to x

**1(c)**

$A_r$ of O = $\frac{(99.76)(15.994) + (0.038)(16.999) + (0.202)(17.999)}{99.76 + 0.038 + 0.202}$ = **16.00**

**1(d)(i)**



**1(d)(ii)**

$$\left| \text{lattice energy} \right| \propto \left| \frac{q_+ \times q_-}{r_+ + r_-} \right|$$

- $O^{2-}$ has higher charge than $NO_3^-$

- $Mg^{2+}$ has smaller cationic radius than $Ca^{2+}$; $O^{2-}$ has smaller anionic radius than $NO_3^-$ ; leading to smaller inter-ionic distance in MgO compared to $Ca(NO_3)_2$.

**2(a)**

A mole of substance is the amount of that substance which contains $6.02 \times 10^{23}$ elementary entities of that substance.

**2(b)**

[Oxidation]: $Fe^{2+} \rightarrow Fe^{3+} + e^-$
[Reduction]: $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

Overall: $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$

**2(c)(i)**
amount of $Cr(OH)_3$ = 0.0588 ÷ [52.0+(16.0)(3)+(1.0)(3)]
= 0.0005708 mol
= $5.71 \times 10^{-4}$ mol

**2(c)(ii)**

amount of $Cr^{3+}$ in 250 $cm^3$ = $0.0005708 \times \frac{250}{25}$
= 0.005708 mol
1 mole of $Cr_2O_7^{2-}$ forms 2 moles of $2Cr^{3+}$
amount of $Cr_2O_7^{2-}$ in 30.00 $cm^3$ = 0.005708 ÷ 2
= 0.00285 mol

**2(c)(iii)**
1 mole of $Cr_2O_7^{2-}$ reacts with 6 moles of $Fe^{2+}$
amount of $Fe^{2+}$ = 0.002854 × 6
= 0.01712 mol

$[Fe^{2+}] = 0.01712 \div \frac{20}{1000}$
= 0.8563 mol $dm^{-3}$
Min. $[Fe^{2+}]$ = 0.857 mol $dm^{-3}$

**3(a)(i)**
A macromolecule built up from monomers, with average molar mass of at least 1000 or at least 100 repeat units.

**3(a)(ii)**
Condensation polymerisation

**3(a)(iii)**

Hydrogen bond

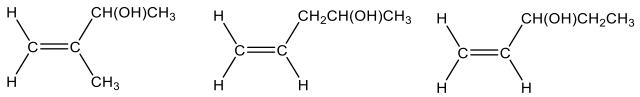
**3(a)(iv)**

Linear chains of cellulose are held in ordered network of hydrogen bonds. When cotton is wet, the hydrogen bonds formed with water molecules results in a different arrangement/shape. When water evaporates, the polymer chains are locked in a new arrangement and hence causes the fabric to crease.

**3(b)(i)**

Compound A is able to exist as cis and trans isomers due to restricted rotation about a C=C bond as a result of the presence of a $\pi$ bond and two different groups attached to each of the two carbon atoms in the double bond.

**3(bii)**




**3(b)(iii)**

Constitutional/ structural isomerism

Accept: Functional group isomer

**4(a)**

$C_7H_{10}O_5$

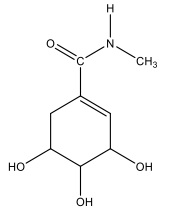
**4(b)(i)**

Add a few drops of $Br_2$ in $CCl_4$ (aq $Br_2$)into a sample containing shikimic.

**4(b)(ii)**

Orange-red $Br_2$ (orange aq. $Br_2$) decolorises in the presence of the alkene functional group.

**4(c)**



Chemical Formula: $C_8H_{13}NO_4$

**4(d)**

| Element | C | H | O |
|---|---|---|---|
| % composition | 35.8 | 4.48 | 100 – 35.8 – 4.48 = 59.72 |
| Molar mass (g $mol^{-1}$) | 12.0 | 1.0 | 16.0 |
| Amount in 100 g of X (mol) | $\frac{35.8}{12.0} = 2.983$ | $\frac{4.48}{1.0} = 4.48$ | $\frac{59.72}{16.0} = 3.7325$ |
| Mole ratio | 1 : | 1.5 : | 1.25 |
| | 4 : | 6 : | 5 |

Hence, the empirical formula of E is $C_4H_6O_5$.

Let molecular formula of E be $(C_4H_6O_5)_n$.

Mr of $(C_4H_6O_5)_n$ = 134
[4(12.0) + 6(1.0) + 5(16.0)] n = 134
n = 1

Hence, the molecular formula of E is $C_4H_6O_5$.

**5(a)(i)**

A catalyst provides an alternative pathway with a lower activation energy to increase the rate of reaction. A heterogeneous catalyst exists in a different phase from the reactants in the reaction.

**5(a)(ii)**

Molecules in canola oil and $H_2$ diffuse and are adsorbed onto the surface of the Ni catalyst by forming weak interactions with Ni. This increases the concentration of reactant molecules at the catalytic surface. The reactant molecules are brought closer together and the covalent bonds within the reactant molecules are weakened which reduces the activation energy for the reaction. The reactants then react on the Ni surface before they desorb and diffuse from the surface of the Ni catalyst, regenerating active sites for other reactant molecules.

**5(b)**

The hydrogenation reaction involving Pt does not require heat, indicating that the reaction with Pt has a lower activation energy as compared to Ni.

**5(c)**

An increase in pressure leads to an increase in amount of hydrogen dissolved in oil, causing an increase in the concentration of hydrogen in oil. This causes reactant molecules to come closer together, increasing frequency of effective collision / increases the adsorption of hydrogen to the surface of Ni.

**5(d)(i)**

$2Li + H_2 \rightarrow 2LiH$

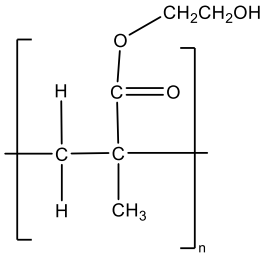
**5(d)(ii)**

Down the group, the number of electron shells increases, causing the valence electron of the metal atom to be more easily lost. Hence, the metals are more easily oxidised and are better reducing agents.

**6(a)(i)**

Alkene, (primary) alcohol and ester

**6(a)(ii)**




Type of polymerisation: Addition polymer

**6(a)(iii)**

They are hard/rigid at room temperature but soft when heated. **Or** They can be melted by heating and molded into shapes when cooled.

**6(a)(iv)**

Covalent bonds (accept Hydrogen bonding)

**6(a)(v)**

Formation of cross-links brings the chains of poly(HEMA) nearer and leads to a less porous structure, which hinders the diffusion of oxygen through the poly(HEMA).

**6(b)(i)**

A weak acid dissociates partially in aqueous solutions to produce $H^+$

**6(b)(ii)**

$$K_a = \frac{[H_2BO_3^-][H^+]}{[H_3BO_3]}$$

**6(b)(iii)**

$pK_a = -\lg (6.31 \times 10^{-10}) = 9.2$

$$7.27 = 9.2 + \lg \left(\frac{[H_2BO_3^-]}{[H_3BO_3]}\right)$$

$$\lg \frac{[H_2BO_3^-]}{[H_3BO_3]} = -1.93$$

$$\frac{[H_2BO_3^-]}{[H_3BO_3]} = 0.0117 \text{ (to 3 sf)}$$

**6(b)(iv)**

$HPO_4^{2-}$

**6(b)(v)**

From Fig. 6.3, at pH 6.5 to pH 7.5, the relative oxygen permeability of the contact lens in both borate and

phosphate buffer is about the same, hence they are equally suitable for storing contact lenses.

**7(a)**

A nanoparticle is a particle with all dimensions of 1-100 nm.

**7(b)**

$TiO_2$ nanoparticles have a greater surface area to volume ratio, increasing the number of active sites for catalytic reactions, producing reactive oxygen species more quickly.

**7(c)**

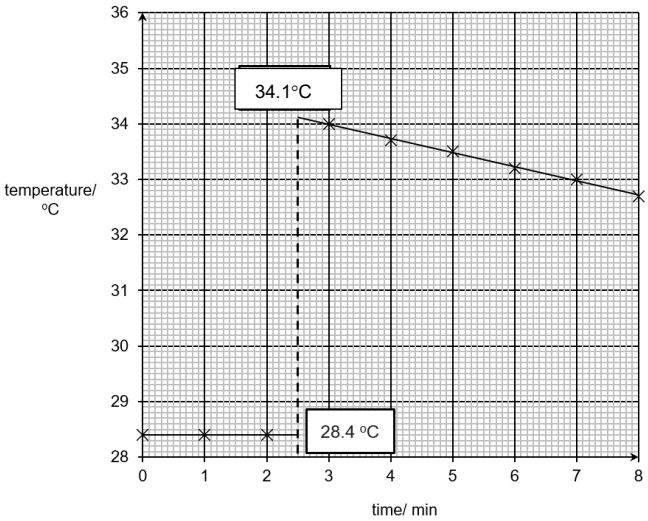
They are small enough to pass through the pores or membranes,(to be absorbed into the body) and into the bloodstream and be carried around to various organs and affect the organs. / or anything reasonable

## Paper 2 Section B

**8(a)**

The standard enthalpy change of neutralisation ($\Delta H^{\ominus}_{neut}$) between an acid and a base is the energy change when the acid and the base react to form 1 mole of water under standard conditions of 1 bar and 298 K.

**8(b)(i)**




**8(b)(ii)**

total volume of solution = 50 + 50 = 100 $cm^3$

q = mc$\Delta$T
= (100)(1.00)(4.18)(+5.7)
= +2382.6 J
≈ +2.38 kJ
Energy evolved = 2.38 kJ

**8(b)(iii)**

$\Delta H_{neut} = -\frac{q}{n_{H_2O}}$
$= -\frac{+2.38}{(\frac{50}{1000}\times 1.00)}$ (note $n_{H2O} = n_{NaOH}$)
$= -47.7$ kJ $mol^{-1}$

**8(c)(i)**

$\Delta H_2 = -1210$ kJ $mol^{-1}$
$\Delta H_3 = (-394) + (-636)$
$= -1030$ kJ $mol^{-1}$

**8(c)(ii)**

$\Delta H_1 = -\Delta H_2 + \Delta H_3$
$= -(-1210) + (-1030)$
$= +180$ kJ $mol^{-1}$

**8(d)(i)**

$K_c = [Ca^{2+}][CO_3^{2-}]$
units = $mol^2\ dm^{-6}$

**8(d)(ii)**

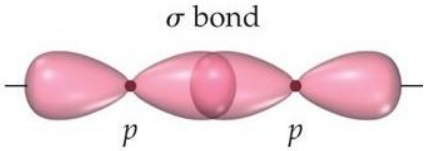
$[Ca^{2+}]_{eqm} = [CO_3^{2-}]_{eqm}$
$= \frac{6.50\times10^{-6}}{(\frac{100}{1000})} = 6.50\times10^{-5}$ mol $dm^{-3}$

$K_c = [Ca^{2+}][CO_3^{2-}]$
$= [6.50\times10^{-5}]\ [6.50\times10^{-5}]$
$= 4.23\times10^{-9}$

**8(d)(iii)**

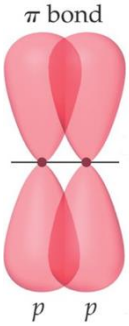
When temperature is increased, the backwards endothermic reaction is favoured to absorb heat. This causes the position of equilibrium to shift left and the equilibrium concentration of $[Ca^{2+}]$ and $[CO_3^{2-}]$ would decrease. Therefore, $K_c$ value would decrease.

**8(e)(i)**




head-on overlap of p orbitals

**8(e)(ii)**




side-to-side overlap of p-orbitals

**8(e)(iii)**

$C_a$ has 4 bond pairs and 0 lone pairs. Hence, to minimise repulsion between electron pairs, the shape about $C_a$ is tetrahedral and the bond angle is 109.5°.

**9(a)(i)**

The electronegativity of an element measures the relative tendency of its atom to attract the shared electron-pair in a covalent bond.

**9(a)(ii)**

Across the period, the bonding in the chlorides of the elements changes from ionic to covalent due to the decreasing difference in electronegativity values between chlorine and the element.

**9(b)**

C*l* has more protons and hence a higher nuclear charge than Na.
Although C*l* has more electrons than Na, the electron is added to the same outermost shell as that of Na, hence shielding effect remains approximately constant (or there is **negligible change** in shielding).

Therefore, C*l* has a stronger electrostatic attraction between the nucleus and its **valence** electrons, resulting in a smaller electron cloud size, therefore a smaller atomic radius.

**9(c)**

$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$
$Na_2O(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$
$Al_2O_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2O(l)$
$Al_2O_3(s) + 2NaOH(aq) + 3H_2O(l) \rightarrow 2Na^+[Al(OH)_4]^-(aq)$
$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$
$SO_3(g) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$

**9(d)**

Electron pairs around the central S atom of a molecule of $SO_2$ are arranged as far apart as possible in space so as to minimise their mutual repulsion.

As there are 2 bond pairs and 1 lone pair of electrons around S, the shape around the central S atom is bent. Since lone pair-bond pair repulsion > bond pair-bond pair repulsion, the bond angle around the central N atom is 118°.

**9(e)(i)**

Water was added in expts 2 and 4 to keep total volume of the reaction mixture constant for the different experiments. In this way, the initial concentration of each reactant in the reaction mixture would be directly proportional to its volume used.

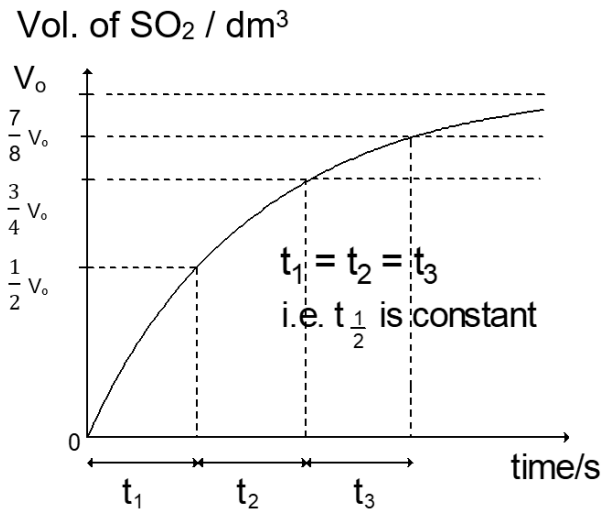
**9(e)(ii)**

By inspection, comparing experiments 1 and 2,
when $[Na_2S_2O_3]$ is doubled, initial rate is doubled
→rate $\propto [Na_2S_2O_3]$
→order of reaction with respect to $Na_2S_2O_3$ is 1.

By inspection, comparing experiments 3 and 4,
when [HC*l*] is doubled, initial rate remains constant
→rate is independent of [HC*l*]
→order of reaction with respect to HC*l* is 0.

rate = $k[Na_2S_2O_3]$

**9(e)(iii)**




**9(e)(iv)**

Constant half-life because it is an overall first order reaction with respect to $[Na_2S_2O_3]$.