Suggested Answers for 2024 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
D	A	A	D	C	D	A	C	B	A	C	C	A	C	B	A	C	C	B	D

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

Worked solutions for Paper 1

Q1

One mole of any substance contains 6.02 x 10^{23} (Avogadro's constant) particles of the substance.

D is correct. Since ethanal exists as a molecule, one mole of ethanal contains 6.02 x 10^{23} ethanal molecules.

Option A is incorrect. Since each molecule of ethanal contains 7 atoms,
number of atoms
= 6.02 x 10^{23} x 7
= 4.21 x 10^{24}

Option B is incorrect. Since each molecule of ethanal contains 2 carbon atoms,
number of carbon atoms
= 6.02 x 10^{23} x 2
= 1.20 x 10^{24}

Option C is incorrect. Since each molecule of ethanal contains 4 hydrogen atoms,
number of hydrogen atoms
= 6.02 x 10^{23} x 4
= 2.41 x 10^{24}

Ans: D

Q2

Oxidation: $\mathrm{A}l \longrightarrow \mathrm{A}l^{3+} + 3e$
One mole of A*l* will lose 3 mol of electrons.

Number of electrons lost from one mole of A*l*
= 3 x 6.02 x 10^{23}

Charge lost from one mole of A*l*
= 3 x 6.02 x 10^{23} x (−1.60 x 10^{-19})
= −288960 C
= −2.89 x 10^{5} C (3 s.f.)

Ans: A

Q3

As 1 mol of MnO_4^- is used, eqns 2 to 4 are each multiplied by a factor to ensure total 5 mol of electrons are involved during each redox reaction.

Multiplying and re-writing equations:

eqn. 1: $MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$

eqn.2 x 2.5: $2.5I_2 + 5e^- \rightleftharpoons 5I^-$

eqn.3 x 5: $5Cu^{2+} + 5e^- \rightleftharpoons 5Cu^+$

eqn.4 x 2.5: $2.5SO_4^{2-} + 5H^+ + 5e^- \rightleftharpoons 2.5SO_3^{2-} + 2.5H_2O$

With reference to the above coefficients,

Option 1 is correct as 1 mol of MnO_4^- reacts with 5 mol of Cu^+ to form 5 mol of Cu^{2+} ions.

Option 2 is incorrect. 1 mol of MnO_4^- reacts with 5 mol of I^- to form 2.5 mol of I_2. If an excess of I^- was used (e.g. 7 mol), MnO_4^- will be the limiting reagent. Since there is 1 mol of MnO_4^- present, 2.5 mol of I_2 will still be produced.

Option 3 is incorrect as MnO_4^- reacts with sulfite (SO_3^{2-}) and not sulfate (SO_4^{2-}). As MnO_4^- gets reduced, it reacts with sulfite, which get oxidised.

Ans: A (1 only)

Q4

W has 12 protons and 10 electrons and is hence Mg^{2+}. Z has 17 protons and 18 electrons and is hence Cl^-. Therefore, option D is correct as $MgCl_2$ is an ionic compound.

Option A is incorrect as W has 2 more protons than electrons, and hence has a charge of 2+.

Option B is incorrect as Z and Y have different numbers of protons and are hence not isotopes.

Option C is incorrect as W (Mg^{2+}) and Y (P^{3-}) form W_3Y_2 (Mg_3P_2) and not W_2Y_3.

Ans: D

Q5
Option C is correct. There is a big jump from the 12th to 13th ionisation energies. Since a lot of energy is required to remove the 13th electron, the 13th electron must be in an inner electronic shell.

Therefore, G has an electronic configuration of $1s^2 2s^2 2p^6 3s^2 3p^2$ since a lot of energy is required to remove the 13th electron from the innermost first electronic shell (n = 1). G is hence Si, which forms the chloride $SiCl_4$.

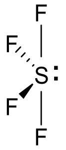
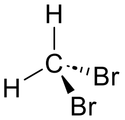
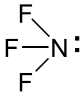
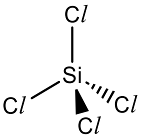
For the same reason, option B is incorrect.

Option A is incorrect as Si is a Period 3 element. G cannot be carbon as carbon only has 6 electrons.

Option D is incorrect as $SiCl_4$ has a simple molecular structure. This is not to be confused with SiO_2, which has a giant molecular structure.

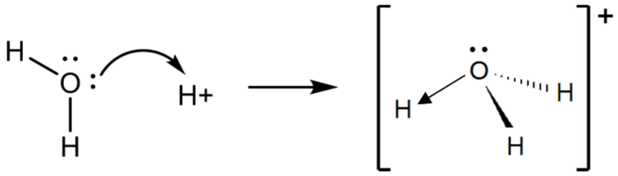
Ans: C

Q6

	shape	structure	polar molecule?
SF_4	see-saw (4 bond pairs, 1 lone pair)		yes
CH_2Br_2	tetrahedral (4 bond pairs)		yes
NF_3	trigonal pyramidal (3 bond pairs, 1 lone pair)		yes
$SiCl_4$	tetrahedral (4 bond pairs)		no

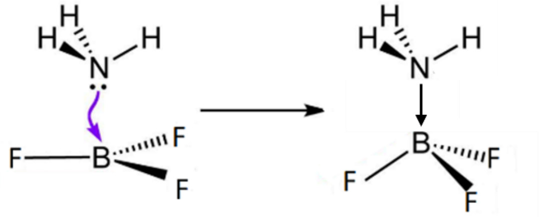
Ans: D

Q7
Option A is correct as H_2O forms a dative covalent bond with H^+ to form H_3O^+, which has a trigonal pyramidal shape about central atom O.



Trigonal pyramidal
(3 bond pairs
1 lone pair)

Option B is incorrect. A dative covalent bond is also formed in option B, but this results in a tetrahedral shape about the central atoms B and N.



Tetrahedral about B and N
(4 bond pairs)

Option C is incorrect as bonds are being broken and not formed.

Option D is incorrect. Although the shape about N in NH_3 is trigonal pyramidal, the N-H bonds formed are covalent bonds, not co-ordinate bonds.

Ans: A

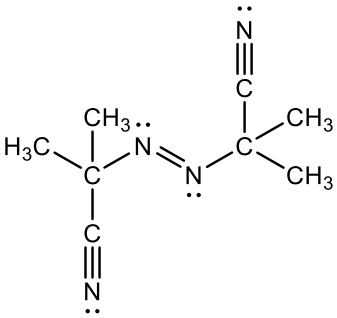
Q8
1 is correct as Br_2 has a larger electron cloud size than NH_3 and hence there are stronger instantaneous dipole-induced dipole (id-id) interactions between Br_2 molecules than NH_3 molecules. The id-id interactions between Br_2 molecules are stronger than the hydrogen bonding and id-id between NH_3 molecules.

2 is incorrect. The electron cloud size of H_2O (10 electrons) is similar to that of NH_3 (10 electrons), which does not explain the significant difference in boiling points of H_2O and NH_3.

3 is correct. Since hydrogen bonds exist between H_2O molecules and between NH_3 molecules, more extensive hydrogen bonds in H_2O than in NH_3 would explain why the boiling point of H_2O is much higher than that of NH_3. H_2O molecules form an average of 2 H–bonds per molecule of H_2O while NH_3 molecules form an average of 1 H–bond per molecule of NH_3.

Ans: C (1 and 3 only)

Q9
Re-drawing the structure of AIBN to include lone pairs of electrons:



Option B is correct since there are 4 lone pairs of electrons in AIBN.

Option A is incorrect since the N atoms in the N=N bond have 2 bond pairs and one lone pair each, so they have a bent shape.

Option C is incorrect as it is linear (2 bond pairs) about C in CN.

Option D is incorrect as AIBN contains 5 π bonds and 23 σ bonds.

Ans: B

Q10
Option A is correct. It is an endothermic reaction as hydrogen bonds between water molecules are broken when water is vaporised.

Option B is an exothermic reaction as more hydrogen bonds are formed between H_2O molecules to freeze H_2O.

Option C is an exothermic reaction as O–H bonds are being formed.

Option D is exothermic as combustion of hydrocarbons is always exothermic.

Ans: A

Q11
$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

Amount of $H_2SO_4 = 50 \times 10^{-3} \times 2.0$
$= 0.1$ mol

Amount of NaOH used $= 100 \times 10^{-3} \times 1.5$
$= 0.15$ mol

Since H_2SO_4 and NaOH react in a 1:2 ratio, NaOH is the limiting reagent. Therefore, amount of H_2O formed = amount of NaOH = 0.15 mol.

$$\Delta H_{neut} = -\frac{q}{n_{H_2O}} = -\frac{mc\Delta T}{0.15} = -\frac{(150)(4.2)(10^{-3})(12.6)}{0.15}$$

$$= \mathbf{-52.9\ kJ\ mol^{-1}}$$

Ans: C

Q12
When given enthalpy change of formation data, $\Delta H_r^{\ominus}$ can be calculated using the following formula:

$$\Delta \boldsymbol{H}_r^{\ominus} = \sum n\Delta \boldsymbol{H}_f^{\ominus}(\text{products}) - \sum m\Delta \boldsymbol{H}_f^{\ominus}(\text{reactants})$$

Applying the formula,

Enthalpy change of combustion of 2 mol of $H_2S(g)$
$= 2(-286) + 2(-297) - 2(-20) = -1126$ kJ mol^{-1}

Enthalpy change of combustion of $H_2S(g)$
$= \frac{-1126\ \text{kJ mol}^{-1}}{2} = \mathbf{-563\ kJ\ mol^{-1}}$

Ans: C

Q13
Let n be the number of half-lives passed.

Initial concentration x $(1/2)^n$ = final concentration
$0.3 \times (1/2)^n = 0.0375$
$(1/2)^n = 0.125$
$n = 3$
$t_{1/2} = 900/3 = 300$ s

From 0.0375 to 0.01875 mol dm^{-3}, another half-life has passed. i.e. n = 4

Total time taken = n x $t_{1/2}$ = 4 x 300 s = **1200 s**

Ans: A

Q14
For both experiments, since rate (gradient) remains constant when [X] decreases, the reaction is zero order with respect to X.

When [Y] = 1.0 mol dm^{-3},

gradient $= \frac{0.10-0.06}{0-4} = -0.01$.
Since rate is always positive, rate = 0.01

When [Y] = 2.0 mol dm^{-3},

gradient $= \frac{0.10-0.02}{0-2} = -0.04$.
Since rate is always positive, rate = 0.04

When [Y] was doubled, rate quadrupled from 0.01 to 0.04 mol dm^{-3} min^{-1}, showing that the reaction is 2nd order with respect to Y.

Therefore, rate = k $[Y]^2$.

Ans: C

Q15

Comparing experiments 1 and 2, when [NO] is kept constant and $[O_2]$ x 0.5, initial rate x 0.5. Therefore, the reaction is first order w.r.t. O_2.

Comparing experiments 1 and 3,

$$\frac{\text{rate}(3)}{\text{rate}(1)} = \frac{k(2.4)(1.2)^n}{k(1.2)(0.6)^n} = \frac{64}{8}$$

$$2 \times 2^n = 8$$

$$n = 2$$

Therefore, the reaction is second order w.r.t. NO.

The rate equation is hence rate = k $[O_2][NO]^2$.

Ans: B

Q16

Option A is correct. When the system reaches dynamic equilibrium, the rate of the forward reaction equals the rate of the reverse reaction.

Option B is incorrect. When the system reaches dynamic equilibrium, the concentrations of the reactants and products remain constant but need not be equal (i.e. [reactants] ≠ [products]).

Option C is incorrect. When the system reaches dynamic equilibrium, the rate of forward reaction equals to the rate of reverse reaction. The rate constant (k) of the forward and reverse reactions need not be equal.

Option D is incorrect. When the system reaches dynamic equilibrium, the forward reaction continues to occur at the same rate as the backward reaction. (dynamic equilibrium). The forward and backward reaction do not stop to occur at equilibrium.

Ans: A

Q17

	$2\ H_2$	CO	CH_3OH
initial amount / mol	2	1	0
change in amount / mol	$-x$	$-\frac{1}{2}x$	$+\frac{1}{2}x$
equilibrium amount / mol	$2 - x$	$1 - \frac{1}{2}x$	$\frac{1}{2}x$

Ans: C

Q18

$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

At 30 °C,
$K_w = [H_3O^+][OH^-] = 1.44 \times 10^{-14}\ \text{mol}^2\ \text{dm}^{-6}$

Since $[H_3O^+] = [OH^-]$,
$[H_3O^+] = \sqrt{1.44 \times 10^{-14}} = 1.20 \times 10^{-7}\ \text{mol dm}^{-3}$
$\text{pH} = -\lg[H_3O^+] = 6.92 < 7.00$

Ans: C

Q19

When a small amount of H^+ ions is added to the solution, the following reaction occurs

$H_2PO_4^-(aq) + H^+(aq) \rightarrow H_3PO_4(aq)$

Hence $[H^+]$ in the solution changes very little and the pH is kept approximately constant.

When a small amount of OH^- ions is added to the solution, the following reaction occurs

$H_3PO_4(aq) + OH^-(aq) \rightarrow H_2PO_4^-(aq) + H_2O(l)$

Hence $[OH^-]$ in the solution changes very little and the pH is kept approximately constant.

Ans: B

Q20

An Arrhenius acid is a hydrogen-containing substance that releases hydrogen ions (i.e. H^+ ions) in aqueous solution.

An Arrhenius base is a hydroxide-containing substance that releases hydroxide ions (i.e. OH^- ions) in aqueous solution.

A BrØnsted-Lowry acid is defined as a proton (H^+) donor while a BrØnsted-Lowry base is defined as a proton (H^+) acceptor.

Option A: NH_3 acts as a nucleophile, while CH_3Cl acts as an electrophile.

Option B: CH_3OH accepts a H^+ ion (BrØnsted-Lowry base), while $HClO_4$ donates a H^+ ion (BrØnsted-Lowry acid).

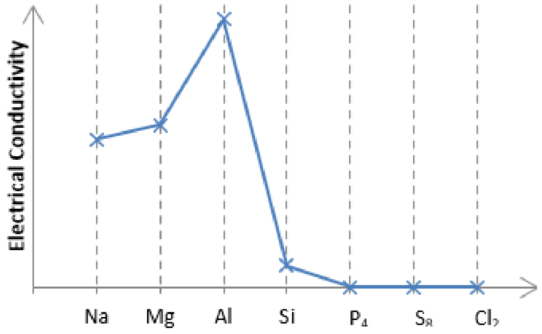
Option C: CH_3COOH donates a H^+ ion (BrØnsted-Lowry acid), while NH_3 accepts a H^+ ion (BrØnsted-Lowry base).

Option D: HNO_3 releases a H^+ ion (Arrhenius acid), while NaOH releases an OH^- ion (Arrhenius base).

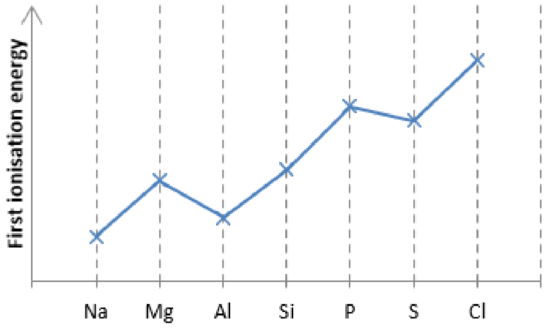
Ans: D

Q21

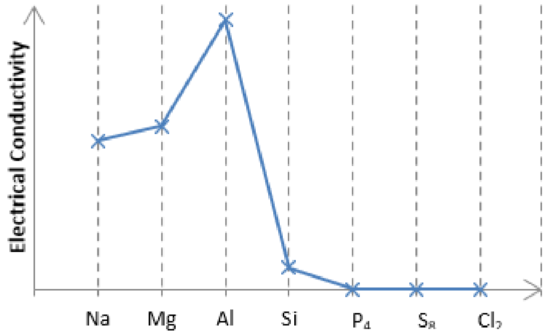
(A)



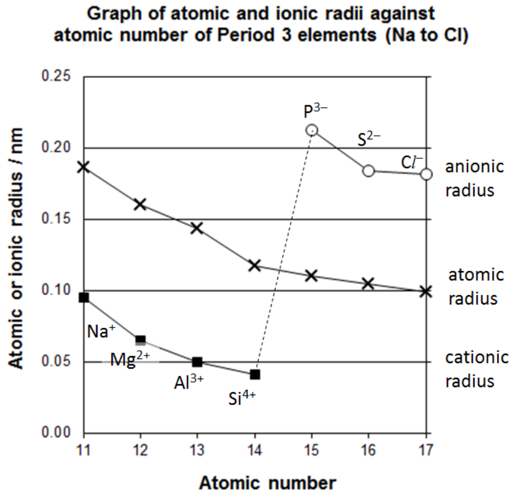
(B)



(C)



(D)



Atomic radius is the only property that decreases consistently from sodium to chlorine

Ans : D

Q22

Ge is in the same group as Si, and therefore $GeCl_4$ will have properties similar to $SiCl_4$.

Option A is incorrect. $GeCl_4$, just like $SiCl_4$, has a simple molecular structure.

Option B is correct.
$SiCl_4$ undergoes hydrolysis as shown.
$SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(aq)$
Thus, $GeCl_4$ is hydrolysed by water too.

Option C is incorrect. $GeCl_4$, just like $SiCl_4$, has a simple molecular structure and thus does not contain delocalised electrons or mobile ions to conduct electricity.

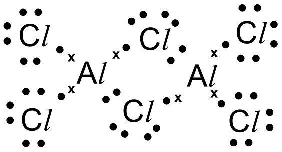
Option D is incorrect. The bond angle in $GeCl_4$, just like $SiCl_4$, is 109.5° (tetrahedral).

Ans: B

Q23

Since In is a Group 13 element, its properties will be similar to that of Al.

Option 1 is correct. A dimer molecule of In_2Cl_6 is structurally similar to Al_2Cl_6.



Option 2 is incorrect. Al_2O_3 does not dissolve in water. Energy needed to break down the ionic lattice is more than the energy released on hydrating the ions. Thus, In_2O_3 is insoluble in water too.

Option 3 is correct. $AlCl_3$ dissolves readily in water with appreciable hydrolysis to produce an acidic solution. Thus, In_2O_3 behaves similarly too.

Hydration:
$AlCl_3(s) + 6H_2O(l) \rightarrow [Al(H_2O)_6]^{3+}(aq) + 3Cl^-(aq)$
Hydrolysis:
$[Al(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons Al(H_2O)_5(OH)]^{2+}(aq) + H_3O^+(aq)$

Ans: B (1 and 3 only)

Q24

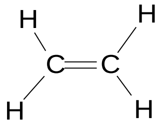
The thermal decomposition of HX involves breaking the H–X bond.

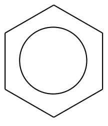
The strength of the covalent H–X bond is dependent on the effectiveness of the orbital overlap.

H–I is weaker than H–C*l* bond since the electron cloud of I is more diffuse than that of C*l*, hence the overlap of orbitals in HI is less effective.

Ans: B

Q25


ethene

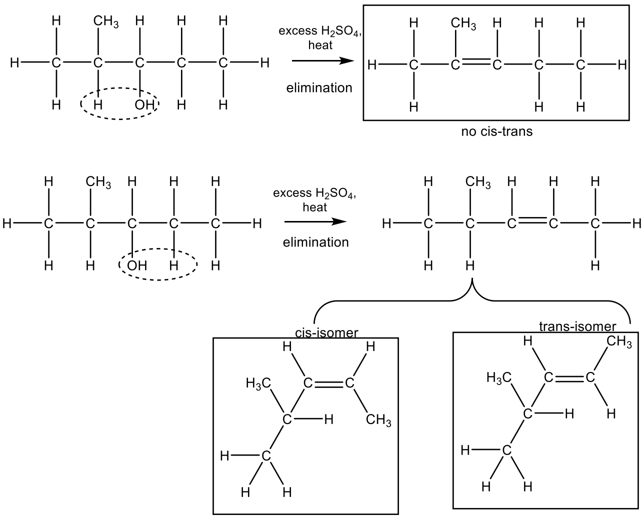

benzene

Option A, B and C are correct. In both molecules, all carbon atoms form three σ bonds and the shape about each carbon atom is trigonal planar.

Option D is incorrect. The shape about each carbon atom in both ethene and benzene is trigonal planar.

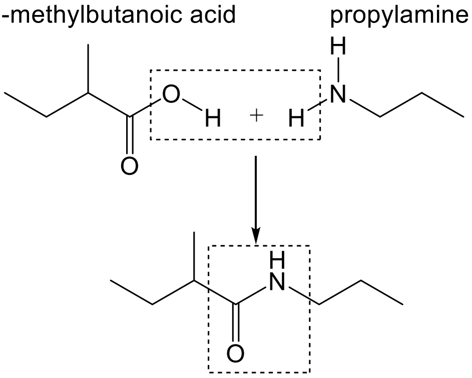
Ans: D

Q26



Ans: B

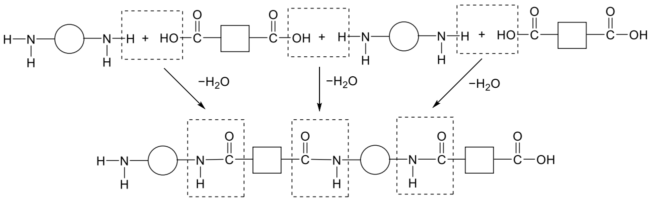
Q27



Ans: A (1 and 4 only)

Q28

For a polyamide constituting of 2 dicarboxylic acids and 2 diamines connected alternately (see diagram below), 2+2−1 = 3 amide bonds are formed and thus 3 molecules of water are removed during condensation.



Hence, for the polyamide **X** constituted of 10 dicarboxylic acid and 10 diamine repeat unit connected alternately and during this process 10+10−1 = 19 amide bonds are formed, thus 19 molecules of water is removed.

Total M_r of polyamide **X**
= 10(116) + 10(146) – 19(18) = 2278

Ans: B

Q29

Option A is a correct statement because HDPE is more linear, with less branching.

Option B is a correct statement because there is more extensive instantaneous dipole−induced dipole (id−id) interactions between polymer chains of HDPE.

Option C is a correct statement because there is more extensive id-id interactions between polymer chains of HDPE.

Option D is an incorrect statement because HDPE is a much stiffer and less flexible material than LDPE. Thus, HDPE is not suitable to make plastic bags.

Ans: D

Q30
Statement 1 is correct. Due to the higher surface area to volume ratio of platinum nanoparticles, there is an increased catalytic efficiency of the catalytic converter in removing pollutants.

Statement 2 is incorrect. Platinum nanoparticles behave as heterogeneous catalysts. They act by allowing reactant molecules to readily adsorb onto the active sites of the catalyst surface, weakening the covalent bonds within the reactant molecules, thereby lowering the activation energy for the reaction. The platinum nanoparticles remain chemically unchanged at the end of the reaction.

Statement 3 is incorrect. Platinum nanoparticles remove carbon monoxide from exhaust fumes by oxidation (not reduction) to form carbon dioxide.

$$2CO(g) + O_2(g) \xrightarrow{Pt} 2CO_2(g)$$

Statement 4 is correct. Platinum nanoparticles remove unburnt hydrocarbons from exhaust fumes by oxidation to form carbon dioxide and water.

$$C_xH_y(g) + (x+\frac{y}{4})\ O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(g)$$

Ans: A (1 and 4 only)

Paper 2

1(a)

	no. of protons	no. of neutrons	no. of electrons	electronic configuration
$^{40}_{19}K$	19	21	19	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
$^{52}_{24}Cr^{3+}$	24	28	21	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$

1(b)(i)
MgO has a giant ionic structure with strong electrostatic forces of attraction between Mg^{2+} and O^{2-} ions.

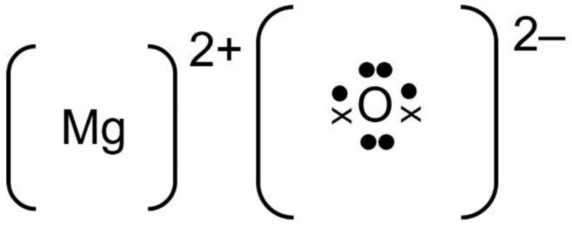
SO_3 has a simple molecular structure with weak instantaneous dipole-induced dipoles interactions between SO_3 molecules.

A larger amount of heat is required to overcome the stronger ionic bonds between the oppositely-charged ions in MgO.

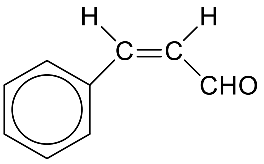
Note:
- write structure and bonding in each compound
- compare strength/amount of energy required

1(b)(ii)
MgO conducts electricity in molten state while SO_3 does not conduct electricity.
or
MgO is only slightly soluble in water and SO_3 reacts readily with water/is soluble in water to form an acidic solution.

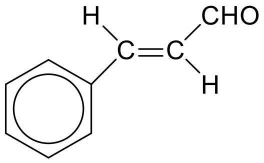
1(b)(iii)



1(c)



cis isomer



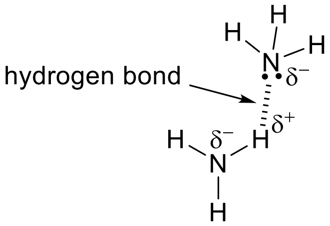
trans isomer

Cis-trans isomerism arises because of the restriction of rotation of C=C double bond.
Also, each carbon atom of C=C must have two different groups attached to it.

2(a)(i)
The volume of the oxygen gas is directly proportional to its temperature.

2(a)(ii)
low temperature and high pressure

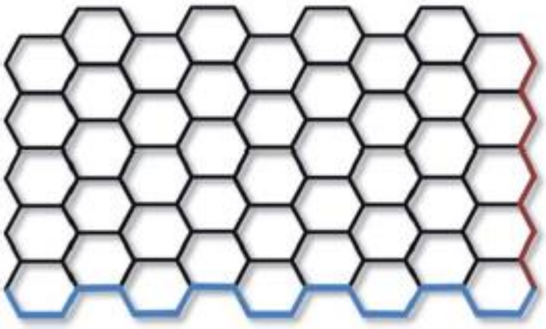
2(a)(iii)



Ammonia molecules are held together by stronger hydrogen bonds compared to the weaker instantaneous dipole-induced dipoles interactions between oxygen molecules and thus can be liquefied by applying pressure at room temperature.

To illustrate H-bonds between NH_3 molecules, need to show:
- δ+ on protonic H
- δ− on N which the protonic H is attached to
- δ− and lone pair on N interacting with the protonic H
- dotted line between the protonic H and lone pair on N, labelled as hydrogen bond

2(b)



Good electrical conductor as one p electron per carbon atom delocalised over the whole graphene layer.

High tensile strength as each carbon atom is attached to 3 others by a network of strong covalent bonds within the graphene layer.

3(a)
The forward reaction is endothermic.

When temperature is increased, the system will try to counteract the increase in temperature by favouring the forward endothermic reaction in order to absorb heat. Equilibrium position shifts right, favouring formation of more hydrogen.

3(b)
When there is a decrease in total pressure, the system will try to counteract the decrease in total pressure by favouring the reaction that increases the total pressure.

Hence, the position of equilibrium shifts to the right as it produces more gas particles and % yield of H_2 increases.

3(c)
increase in temperature

The forward reaction is endothermic. When temperature increases, the position of equilibrium shifts to the right to absorb heat so as to decrease the temperature of the equilibrium system.

Hence, more products are formed and there are less reactants, and the value of K_c increases.

introduction of a catalyst

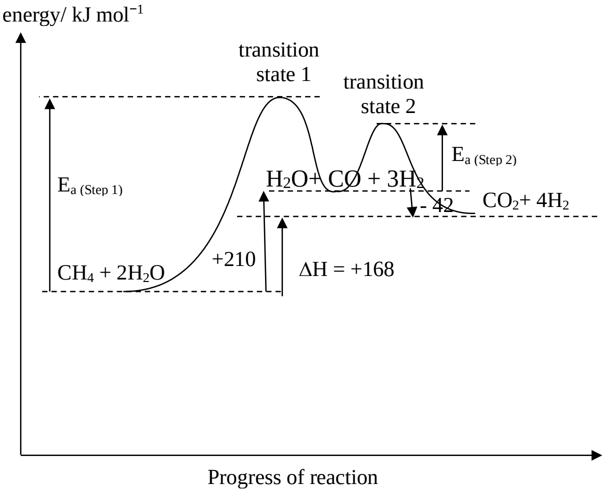
When a catalyst is added, the value of K_c remains the same, as the rates of both the forward and backward reactions are increased to the same extent.

3(d)
When temperature is increased from T_1 to T_2 K, the average kinetic energy of the reactant particles increases.

As such, significantly more reactant particles have energy greater than or equal to the activation energy of the reaction.

This results in an increase in effective collision frequency and hence an increase in the rate of the reaction.

3(e)



4(a)
2-hydyroxypropanoic acid

4(b)
$CH_3CH(OH)CO_2H + NaOH \longrightarrow CH_3CH(OH)CO_2^-Na^+ + H_2O$

4(c)
amount of lactic acid = amount of NaOH used

$= 0.005 \times 16 \div 1000$

$= 8.00 \times 10^{-5}$ mol

[lactic acid] in diluted milk

$= 8.00 \times 10^{-5} \times 1000 \div 10$

$= 8.00 \times 10^{-3}$ mol dm^{-3}

[lactic acid] in original sample of milk

$= 8.00 \times 10^{-3} \times 100 \div 10$

$= 8.00 \times 10^{-2}$ mol dm^{-3}

4(d)
Mass of 1 dm^3 of milk

$= 1.04 \times 1000$

$= 1.04 \times 10^3$ g

Mass of lactic acid in 1 dm^3 of milk

$= 8.00 \times 10^{-2} \times (3\times12 + 3\times16 + 6)$

$= 7.20$ g

% by mass of lactic acid

$= (7.20 \div 1040) \times 100\%$

$= 0.692\ \% < 1\%$

The milk would taste pleasant.

4(e)

thymolphthalein (as this is a weak acid−strong base titration)

A suitable indicator is one where its pH range coincides with the region of rapid pH change in the titration curve (i.e. the pH range of the indicator must fall on the vertical portion of the titration curve).

5(a)

- mass of the weights used
- type of cloth used/permeability
- mass of curds wrapped in cloth
- volume of water/liquid squeezed out
- time taken
- temperature

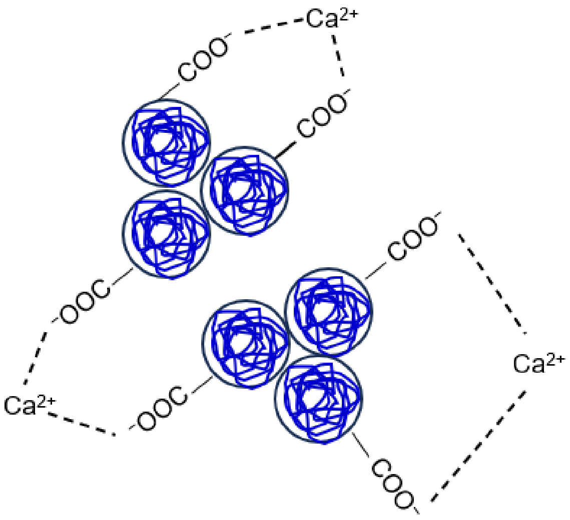
5(b)

The electrostatic negative charges in protein molecules repel one another and this decreases the amount of protein-protein interactions and their tendency to aggregate and precipitate.

5(c)

Nigari is obtained from seawater which is abundant and is readily available.

5(d)



forces of attraction – ionic

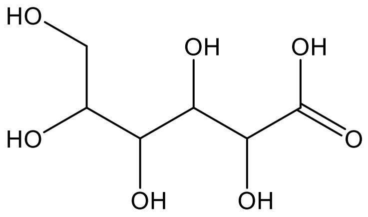
5(e)

There is a higher protein content in tofu when $CaSO_4$ is added.

This is because the protein molecules are less soluble in the presence of $CaSO_4$ and are filtered/precipitated out.

5(f)

GDL undergoes hydrolysis to form (gluconic) acid.



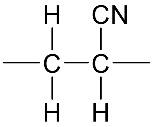
structural formula of product

5(g)

acid coagulant e.g. lemon juice

6(a)

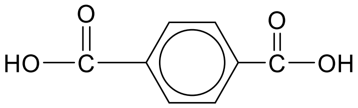
repeat unit of polymer **Y**



$$\begin{array}{ccccc} & \mathrm{H} & & \mathrm{CN} & \\ & | & & | & \\ - & \mathrm{C} & - & \mathrm{C} & - \\ & | & & | & \\ & \mathrm{H} & & \mathrm{H} & \end{array}$$

type of polymerisation: addition

6(b)(i)



$HO—CH_2CH_2—OH$

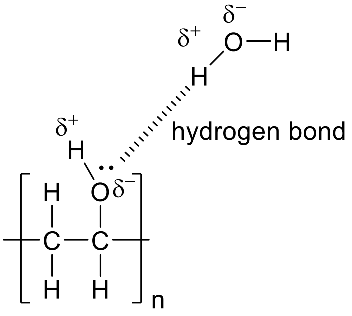
6(b)(ii)

PET is crease/wrinkle resistant.

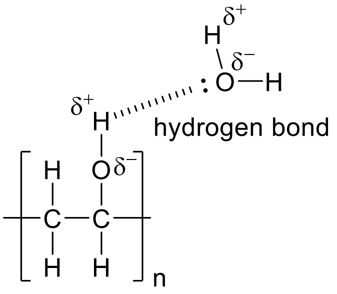
6(b)(iii)

A thermoplastic polymer can be melted and remolded into shapes that are retained when the polymer is cooled.

6(c)



OR



This is due to the –OH group in PVA which can form hydrogen bonds with water molecules.

7(a)(i)

The standard enthalpy change of formation ($\Delta H_f^\ominus$) of a substance is the energy change when 1 mole of the pure substance in a specified state is formed from its constituent elements in their standard states under standard conditions of 298 K and 1 bar.

7(a)(ii)

$4\,\Delta H_2 + \Delta H_1 = \Delta H_3$

7(a)(iii)

$4\,\Delta H_2 + \Delta H_1 = \Delta H_3$

$4\Delta H_f^\ominus(NH_4NO_3) + \Delta H_1 = 2\Delta H_f^\ominus(NO_2) + 8\Delta H_f^\ominus(H_2O)$

$\Delta H_1 = –4(−365.6) + 2(+33.2) + 8(–241.8)$

$\Delta H_1 = –405.6$

$= −406\ \text{kJ mol}^{-1}$ (3s.f.)

7(b)(i)

The bonding in $\mathrm{MgC}l_2$ is ionic as there is a large difference in electronegativity of Mg and C*l*.

The bonding in $\mathrm{SiC}l_4$ is covalent as Si and C*l* have similar electronegativities.

7(b)(ii)

$\mathrm{MgC}l_2(s) + 6H_2O(l) \rightarrow [Mg(H_2O)_6]^{2+}(aq) + 2\mathrm{C}l^-(aq)$

$[Mg(H_2O)_6]^{2+}(aq) \rightleftharpoons [Mg(H_2O)_5(OH)]^+(aq) + H^+(aq)$

pH = 6.5

$\mathrm{SiC}l_4(l) + 2H_2O(l) \longrightarrow SiO_2(s) + 4\mathrm{HC}l(aq)$

pH = 2

7(b)(iii)

As the charge density of Fe^{3+} is lower than $\mathrm{A}l^{3+}$, ability to polarise the water molecules is lower than $\mathrm{A}l^{3+}$. Hence, the extent of hydrolysis is lower, so the pH of Fe^{3+} solution will be greater than that of $\mathrm{A}l^{3+}$.

7(c)

I_2 cannot be reduced to I^- as it is more difficult for I_2 to gain electrons than $\mathrm{C}l_2$ to form anions. i.e. it is more difficult for I_2 to be reduced.

7(d)

reaction I

substitution reaction

NaOH(aq) or KOH(aq), heat

7(d)

reaction II

elimination reaction

KOH in ethanol **OR** ethanolic KOH, heat

7(e)(i)

A Brønsted-Lowry acid is a proton donor.

A strong acid undergoes complete dissociation in aqueous solution to produce $H^+(aq)$.

7(e)(ii)

acid:	$\mathrm{HC}l$		conjugate base:	$\mathrm{C}l^-$
base:	OH^-		conjugate acid:	H_2O

7(e)(iii)

$\mathrm{NaOH} + \mathrm{HC}l \longrightarrow \mathrm{NaC}l + H_2O$

Amount of HC*l* = $\frac{0.200}{1000} \times 14 = 2.80 \times 10^{-3}$ mol

Amount of NaOH = $\frac{0.100}{1000} \times 20 = 2.00 \times 10^{-3}$ mol

Amount of H^+ in resultant solution

$= 2.80 \times 10^{-3} - 2.00 \times 10^{-3}$

$= 8.00 \times 10^{-4}$ mol

pH of the resultant solution

$= -\lg\left(\frac{8 \times 10^{-4}}{14.00+20.00} \times 1000\right)$

= 1.63

8(a)

Let m be the relative atomic mass of the third isotope.

$$40.11 = \frac{95x40 + 1x43 + 4xm}{100}$$

m = 42.0

8(b)(i)

Element	Ca	O	C*l*
% composition	31.5	12.6	100 – 31.5 – 12.6 = 55.9
molar mass / g mol^{-1}	40.1	16.0	35.5
amount in 100 g of **Q**/ mol	$\frac{31.5}{40.1}=0.786$	$\frac{12.6}{16.0}=0.788$	$\frac{55.9}{35.5}=1.574$
molar ratio	1 :	1 :	2

Hence, the empirical formula of **Q** is $CaOCl_2$.

8(b)(ii)

Let molecular formula of **Q** be $(CaOCl_2)_n$

$$M_r \text{ of } (CaOCl_2)_n = 127.1$$
$$[40.1 + 16.0 + 2(35.5)]\ n = 127.1$$
$$n = 1$$

Hence, the molecular formula of **Q** is $CaOCl_2$.

8(c)(i)

$$K_a = \frac{[H^+][ClO^-]}{[HClO]}$$

8(c)(ii)

$[HClO] = 1 \times 10^{-4} - x$

8(c)(iii)

$$K_a = \frac{[H^+][ClO^-]}{[HClO]}$$

$$3.0x10^{-8} = \frac{[10^{-6}][x]}{[1 \times 10^{-4} - x]}$$

$x = 2.91 \times 10^{-6}$ mol dm^{-3}

$[HClO] = 1 \times 10^{-4} - 2.91 \times 10^{-6}$
$= 9.71 \times 10^{-5}$ mol dm^{-3}

8(d)

Both Na and C*l* are in the same period. Across the period, both have the same number of electronic shells, but C*l* has more protons and hence a higher nuclear charge. Shielding effect remains approximately constant as electrons are added to the same outermost shell. Therefore, the effective nuclear charge of C*l* is higher.

Electrostatic attraction between the nucleus and valence electron of C*l* is stronger, resulting in a larger amount of energy required to remove a valence electron from C*l* as compared to Na.

Thus, C*l* has a higher first ionisation energy than Na atom.

8(e)

Cl^- has one more electronic shell than Na^+. For Cl^-, the distance between the nucleus and the outermost electrons is higher, hence, the shielding experienced by outermost electrons of Cl^- is higher.

Despite Cl^- having higher nuclear charge, electrostatic attraction between its nucleus and its outermost electrons is weaker, resulting in a larger size of the electron cloud.

8(f)(i)

factor 1	product of ionic charges
factor 2	inter-ionic distance

8(f)(ii)

In SrS, Sr^{2+} and S^{2-} are both doubly charged.

In NaC*l*, Na^+ and Cl^- are both singly charged.

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

Or lattice energy is proportional to I q+ × q- I,

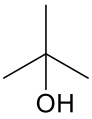
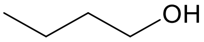
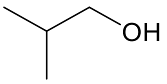
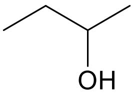
Thus, the lattice energy of SrS is more exothermic than that of NaC*l*.

8(g)(i)

oxidation

8(g)(ii)

H, **I** and **J** are alcohols which undergo elimination of H_2O to form alkenes.

	 Or 	
H	**I**	**J**

Note:
3° alcohol **H** is resistant to oxidation
1° alcohol **I** oxidises to carboxylic acid.
2° alcohol **J** oxidises to ketone.