

**NATIONAL JUNIOR COLLEGE**  
**SH2 PRELIMINARY EXAMINATION**  
Higher 1

CANDIDATE  
NAME

SUBJECT  
CLASS

REGISTRATION  
NUMBER

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**CHEMISTRY**

Paper 1 Multiple Choice

Additional Materials:

Optical Answer Sheet  
Data Booklet

**8873/01**

**Thur 13 September 2018**

**1 hour**

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**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, subject class and registration number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **30** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

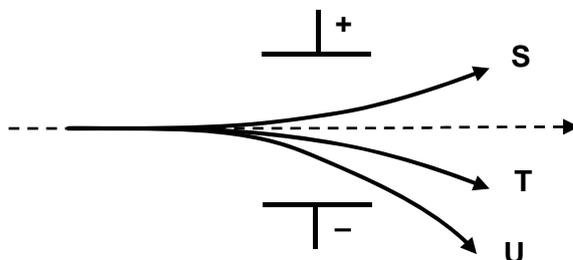
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This paper consists of **14** printed pages

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 *Use of the Data Booklet is relevant to this question.*

The following are flight paths of charged particles when accelerated in an electric field.



Which of the following correctly identifies **S**, **T** and **U**?

|          | <b>S</b>          | <b>T</b>              | <b>U</b>              |
|----------|-------------------|-----------------------|-----------------------|
| <b>A</b> | $^{15}\text{O}^+$ | $^{14}\text{C}^+$     | $^{14}\text{N}^+$     |
| <b>B</b> | $^{15}\text{O}^-$ | $^{15}\text{O}^+$     | $^{28}\text{Si}^+$    |
| <b>C</b> | $^{14}\text{N}^-$ | $^{28}\text{Si}^{2+}$ | $^{14}\text{C}^{2+}$  |
| <b>D</b> | $^{14}\text{N}^-$ | $^{14}\text{C}^+$     | $^{28}\text{Si}^{2+}$ |

- 2 An element **L** can exist in a few oxidation states. 0.1 mol of  $\text{L}^{2+}$  requires 0.04 mol of acidified  $\text{KMnO}_4$  for complete reaction.

The half equation for reduction of  $\text{MnO}_4^-$  is



What is the final oxidation state of **L**?

- A** +4                      **B** +3                      **C** 0                      **D** -1

- 3 *Use of Data Booklet is relevant to this question.*

Nickel makes up 20% of the total mass of a coin. The coin has a mass of 10.0 g.

How many nickel atoms are in the coin?

- A**  $2.05 \times 10^{22}$       **B**  $4.30 \times 10^{22}$       **C**  $1.03 \times 10^{23}$       **D**  $1.20 \times 10^{24}$

4 Which compound has an unpaired electron in its structure?

- A  $\text{N}_2\text{O}_4$                       B  $\text{BCl}_3$                       **C** NO                      D  $\text{NP}_3$

5 In which sequence is the molecules listed in the order of increasing dipole moment?

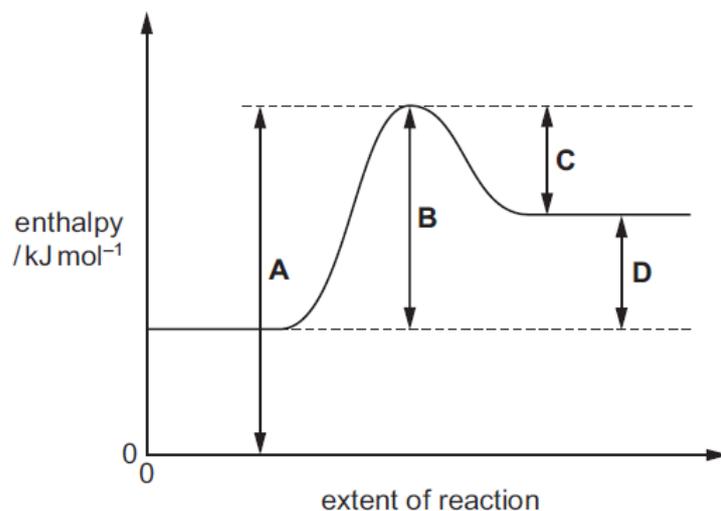
- A**  $\text{CH}_4$ , CO, HF  
 B  $\text{H}_2\text{O}$ ,  $\text{H}_2\text{S}$ , HBr  
 C  $\text{SO}_3$ ,  $\text{CO}_2$ ,  $\text{AlCl}_3$   
 D  $\text{NH}_3$ , HF,  $\text{BeCl}_2$

6 The  $\text{C}_2\text{H}_2$  molecule is linear.

What can be deduced from this about the numbers of  $\sigma$  and  $\pi$  bonds present in the molecule?

|          | $\sigma$ | $\pi$ |
|----------|----------|-------|
| A        | 2        | 2     |
| B        | 2        | 3     |
| C        | 3        | 1     |
| <b>D</b> | 3        | 2     |

7 The diagram shows a reaction pathway for an endothermic reaction.



Which arrow represents the activation energy for the forward reaction?

- 8 The standard enthalpy changes of combustion of carbon are as follows.

$$\text{C}(\text{graphite}) = -393 \text{ kJ mol}^{-1}$$

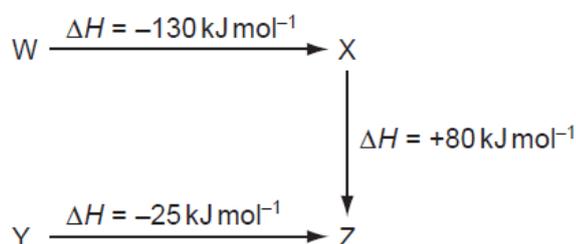
$$\text{C}(\text{diamond}) = -395 \text{ kJ mol}^{-1}$$

Which deductions can be made from the data above?

- 1 Graphite is more stable than diamond.
- 2 Graphite has a higher energy content than diamond.
- 3 Graphite is formed endothermically from diamond.

A 1, 2 and 3      B 2, and 3      C 1 and 3 only      **D 1 only**

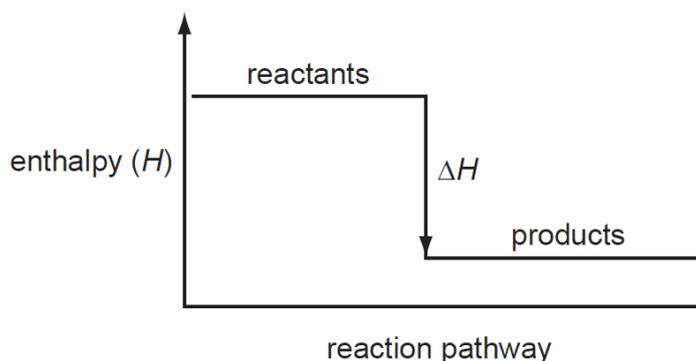
- 9 The diagram represents the energy changes for some reactions.



What are the natures of the conversions  $W \rightarrow Y$ ,  $Y \rightarrow X$  and  $Z \rightarrow W$ ?

|          | $W \rightarrow Y$ | $Y \rightarrow X$ | $Z \rightarrow W$ |
|----------|-------------------|-------------------|-------------------|
| <b>A</b> | exothermic        | endothermic       | endothermic       |
| <b>B</b> | exothermic        | exothermic        | endothermic       |
| <b>C</b> | endothermic       | exothermic        | exothermic        |
| <b>D</b> | endothermic       | endothermic       | exothermic        |

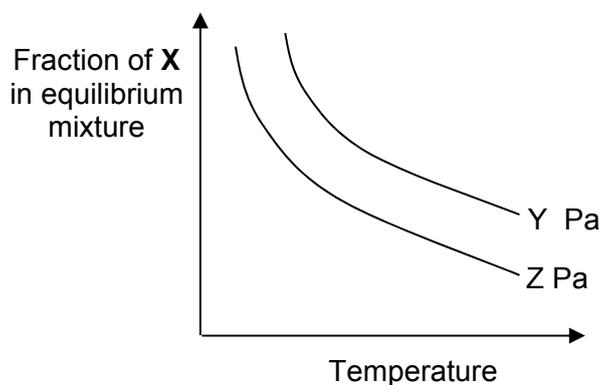
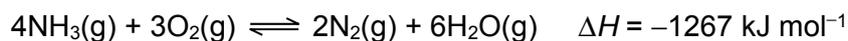
- 10 Which enthalpy change could **not** be correctly represented by the enthalpy diagram shown?



- A** standard enthalpy change of atomisation
- B standard enthalpy change of combustion
- C standard enthalpy change of hydration
- D standard enthalpy change of neutralisation



- 13 The graph below shows how the fraction of **X**, which represents one of the following compounds in the equilibrium mixture shown below, varies with temperature at pressures of Y Pa and Z Pa.



Identify **X** and the correct relative magnitudes of Y and Z.

|          | <b>X</b>             | <b>Pressure</b> |
|----------|----------------------|-----------------|
| <b>A</b> | <b>N<sub>2</sub></b> | <b>Z &gt; Y</b> |
| <b>B</b> | O <sub>2</sub>       | Y > Z           |
| <b>C</b> | H <sub>2</sub> O     | Y > Z           |
| <b>D</b> | NH <sub>3</sub>      | Z > Y           |

- 14 One of the key production stages in the Contact Process is the production of sulfur trioxide.

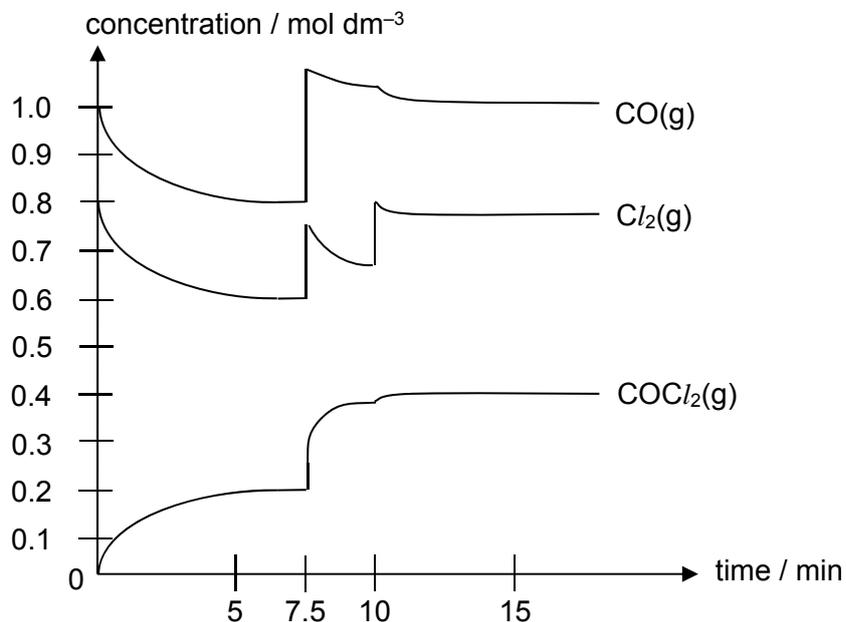
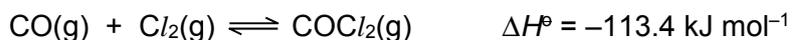


The rate constants of the forward and backward reactions are given as  $k_1$  and  $k_{-1}$  respectively.

What happens to  $k_1$ ,  $k_{-1}$  and  $K_c$  if the temperature of the reaction is increased?

|          | $k_1$           | $k_{-1}$        | $K_c$           |
|----------|-----------------|-----------------|-----------------|
| <b>A</b> | increase        | increase        | no change       |
| <b>B</b> | increase        | decrease        | increase        |
| <b>C</b> | decrease        | increase        | decrease        |
| <b>D</b> | <b>increase</b> | <b>increase</b> | <b>decrease</b> |

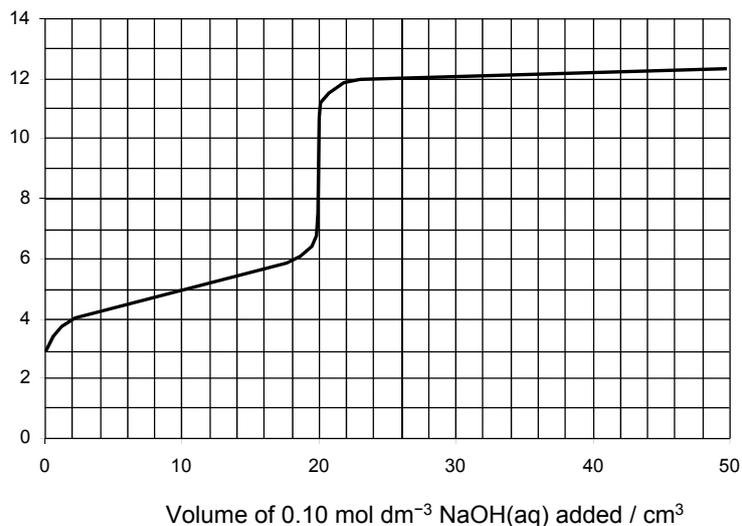
- 15 The reaction between carbon monoxide and chlorine was studied in an experiment by mixing the two gases and changing the reaction conditions inside the reaction vessel at different times during the experiment. The concentrations of the gases in the vessel were followed with time, and the following graph is obtained.



Which conclusion deduced from the graph is **incorrect**?

- A The rate of forward reaction equals the rate of backward reaction at 7 min.
- B The equilibrium constant,  $K_c$ , for the system when determined at 7 min is  $2.4 \text{ mol}^{-1} \text{ dm}^3$ .
- C The change in concentration from 7.5 min to 10 min was produced by an decrease in volume at constant temperature.
- D The change in concentration from 10 min to 15 min was produced by the addition of more chlorine.

- 16 The titration curve below shows the reaction between 20.0 cm<sup>3</sup> of HX, and aqueous sodium hydroxide.



Given the following data:

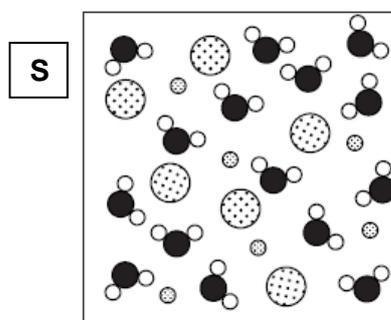
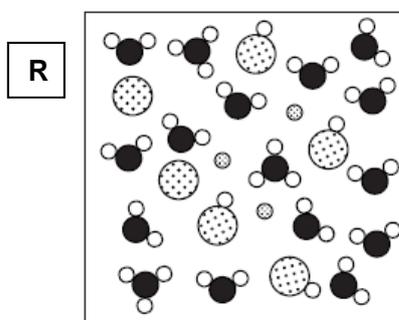
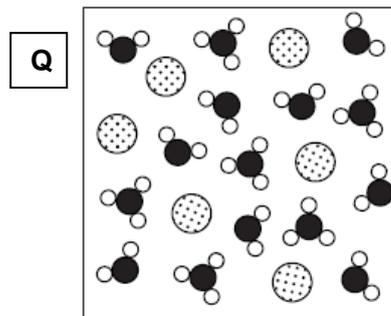
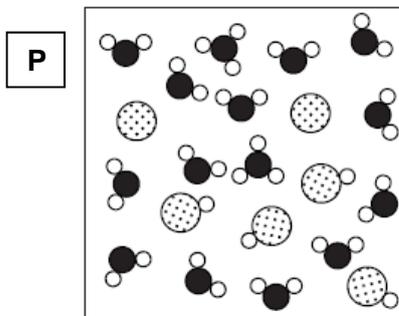
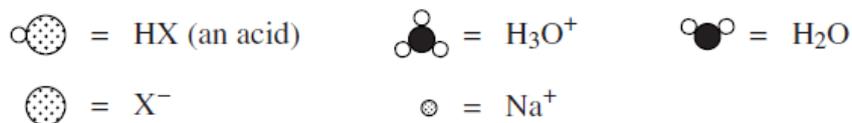
| Indicator        | Colour change<br>(acidic to basic medium) | pH range in which colour<br>change occurs |
|------------------|---|---|
| Methyl red       | red to yellow                             | 4.2 – 6.3                                 |
| Bromothymol blue | yellow to blue                            | 6.0 – 7.6                                 |
| Thymolphthalein  | colourless to blue                        | 8.3 – 10.5                                |

What statements are correct?

- 1 Methyl red is the most suitable indicator to be used for this titration.
- 2 Initial concentration of HX is 0.10 mol dm<sup>-3</sup>.
- 3 When 10.0 cm<sup>3</sup> of NaOH is added, [H<sup>+</sup>] in the mixture is 1.00 × 10<sup>-5</sup> mol dm<sup>-3</sup>.

A 1, 2 and 3      **B 2, and 3**      C 1 and 3 only      D 3 only

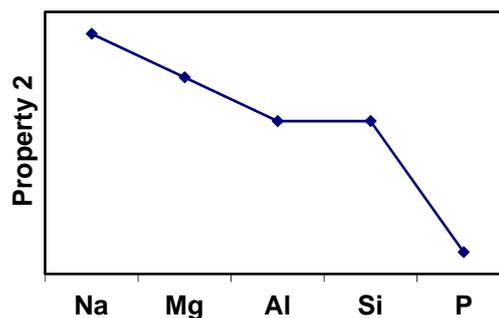
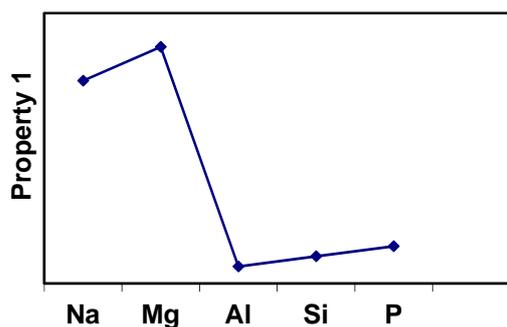
- 17 The diagrams represent some dilute aqueous solutions. In all cases, only a few of the large numbers of water molecules are shown.



Which option correctly describes the solutions represented by the diagrams?

|          | <b>P</b>      | <b>Q</b>      | <b>R</b>  | <b>S</b>  |
|----------|---------------|---------------|---|---|
| <b>A</b> | a strong acid | a weak acid   | a salt formed by neutralising a strong acid with sodium hydroxide | weak acid partially neutralised by sodium hydroxide               |
| <b>B</b> | a weak acid   | a strong acid | a salt formed by neutralising a strong acid with sodium hydroxide | weak acid partially neutralised by sodium hydroxide               |
| <b>C</b> | a strong acid | a weak acid   | weak acid partially neutralised by sodium hydroxide               | a salt formed by neutralising a strong acid with sodium hydroxide |
| <b>D</b> | a weak acid   | a strong acid | weak acid partially neutralised by sodium hydroxide               | a salt formed by neutralising a strong acid with sodium hydroxide |

- 18 The graphs below show the variation of two properties of some period 3 elements and/or their compounds.



Which correctly describes properties 1 and 2?

**Property 1**

**Property 2**

- |          |  |   |
|----------|--|---|
| <b>A</b> | atomic radius of the elements                          | electrical conductivity of the elements                         |
| <b>B</b> | boiling point of the highest oxidation state chlorides | pH of the highest oxidation state oxides when added to water    |
| <b>C</b> | melting point of the highest oxidation state oxides    | first ionisation energies of the elements                       |
| <b>D</b> | electrical conductivity of elements                    | pH of the highest oxidation state chlorides when added to water |

- 19 Element **H** is in Period 3 of the Periodic Table. The following four statements were made about the properties of element **J** or its compounds.

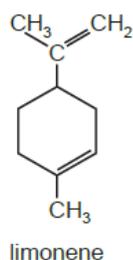
Three statements are correct descriptions and one is false.

Which statement does **not** fit with the other three?

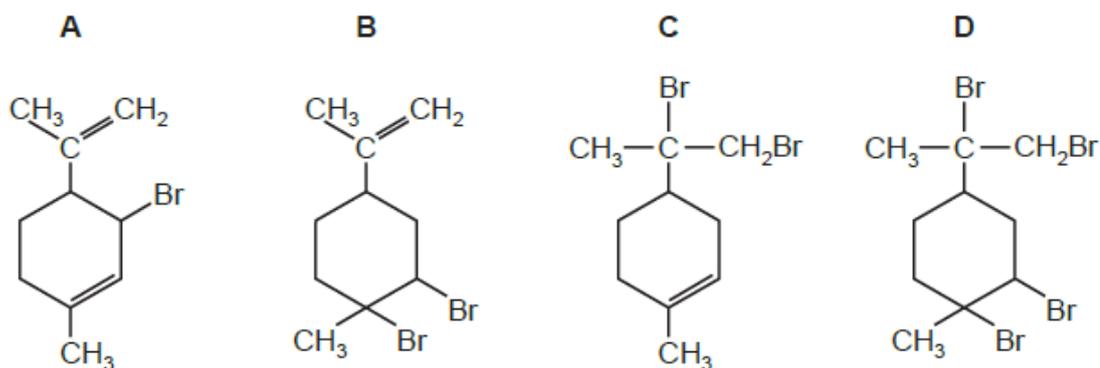
- A** Adding NaOH(aq) to the solution resulting from the reaction of a chloride of **J** with water produces a white precipitate which is soluble in an excess of NaOH(aq).
- B** Element **H** is a solid at room temperature.
- C** Element **H** has the highest melting point among the period 3 elements.
- D** The oxide of element **H** is soluble in hydrochloric acid.



- 25 Limonene is an oil formed in the peel of citrus fruits.



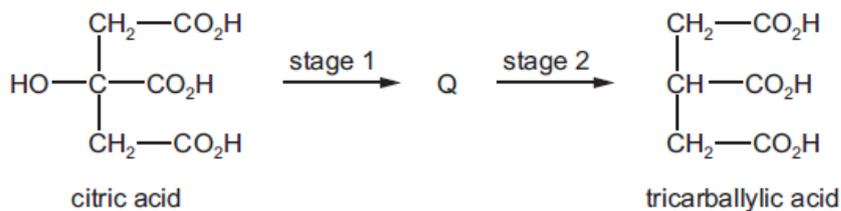
Which product is formed when an excess of bromine,  $\text{Br}_2(\text{l})$  reacts with limonene at room temperature in the dark?



- 26 Which compound is a product of the hydrolysis of  $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{CH}_3$  by boiling aqueous sodium hydroxide?

**A**  $\text{CH}_3\text{OH}$       **B**  $\text{C}_3\text{H}_7\text{OH}$       **C**  $\text{C}_3\text{H}_7\text{CO}_2\text{H}$       **D**  $\text{C}_3\text{H}_7\text{CO}_2^-\text{Na}^+$

- 27 Citric acid can be converted into tricarballic acid in two stages. An intermediate, Q, is formed.



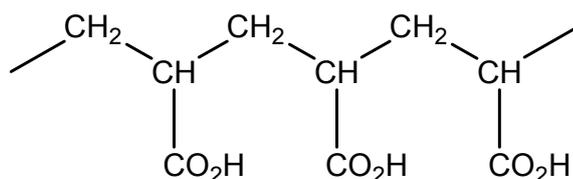
Which reagents are needed for each stage?

| stage 1                                       | stage 2                            |
|---|------------------------------------|
| <b>A</b> Concentrated $\text{H}_2\text{SO}_4$ | $\text{H}_2(\text{g})$ and Ni      |
| <b>B</b> Concentrated $\text{H}_2\text{SO}_4$ | $\text{LiAlH}_4$                   |
| <b>C</b> $\text{LiAlH}_4$                     | $\text{H}_2\text{SO}_4(\text{aq})$ |
| <b>D</b> $\text{NaOH}(\text{aq})$             | $\text{H}_2(\text{g})$ and Ni      |

28 Which statements are correct for monomers and polymers involved in addition polymerization?

- 1 The monomers contain at least one unsaturated bond.
  - 2 Empirical formula of the addition polymer is the same as that of its monomer.
  - 3 Poly(vinyl alcohol) is formed via addition polymerization and can form hydrogen bonds between its adjacent molecules.
  - 4 Low density poly(ethene) (LDPE) and high density poly(ethene) (HDPE) are addition polymers but differ in their monomers.
- A All correct.  
 B 1, 2 and 3  
 C 1 and 2  
 D 1, 2 and 4

29 The absorbent material in babies' disposable nappies is made from the polymer



From which monomer could this polymer be obtained?

- A  $\text{C}/\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$   
 B  $\text{HOCH}_2\text{CH}_2\text{CO}_2\text{H}$   
 C  $\text{H}_2\text{C}=\text{CHCO}_2\text{H}$   
 D  $\text{HO}_2\text{CCH}=\text{CHCO}_2\text{H}$
- 30 Chlorofluorocarbons (CFCs) are commonly used as aerosols, propellants and refrigerants. However in the stratosphere, CFCs can damage the ozone layer through a radical chain reaction.

In which sequence are the following compounds listed in increasing order of their ability to destroy ozone?

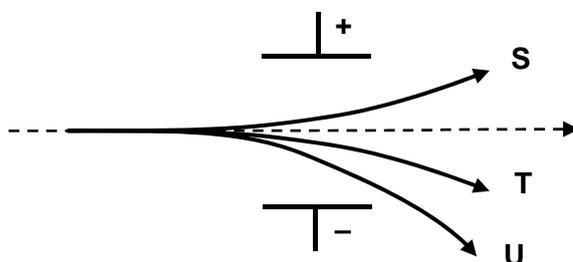
- A  $\text{CHC}/\text{FCC}/\text{F}_2 < \text{CCl}_2\text{FCCl}_2\text{F} < \text{CHC}/\text{F}_2$   
 B  $\text{CCl}_2\text{FCCl}_2\text{F} < \text{CHC}/\text{F}_2 < \text{CHC}/\text{FCC}/\text{F}_2$   
 C  $\text{CHC}/\text{F}_2 < \text{CCl}_2\text{FCCl}_2\text{F} < \text{CHC}/\text{FCC}/\text{F}_2$   
 D  $\text{CHC}/\text{F}_2 < \text{CHC}/\text{FCC}/\text{F}_2 < \text{CCl}_2\text{FCCl}_2\text{F}$

End of Paper

**NJC 2018 SH2 H1 Chemistry Paper 1 Solutions:**

- 1 Use of the Data Booklet is relevant to this question.

The following are flight paths of charged particles when accelerated in an electric field.



Which correctly identifies **S**, **T** and **U**?

|          | <b>S</b>          | <b>T</b>              | <b>U</b>              |
|----------|-------------------|-----------------------|-----------------------|
| <b>A</b> | $^{15}\text{O}^+$ | $^{14}\text{C}^+$     | $^{14}\text{N}^+$     |
| <b>B</b> | $^{15}\text{O}^-$ | $^{15}\text{O}^+$     | $^{28}\text{Si}^+$    |
| <b>C</b> | $^{14}\text{N}^-$ | $^{28}\text{Si}^{2+}$ | $^{14}\text{C}^{2+}$  |
| <b>D</b> | $^{14}\text{N}^-$ | $^{14}\text{C}^+$     | $^{28}\text{Si}^{2+}$ |

**C:** Negatively charged ions (T and U) attracted to positive plate, positive ions (S) to negative plate.

|              |                   |                      |                   |                       |                   |
|--------------|-------------------|----------------------|-------------------|-----------------------|-------------------|
| particles    | $^{14}\text{N}^-$ | $^{14}\text{C}^{2+}$ | $^{14}\text{C}^+$ | $^{28}\text{Si}^{2+}$ | $^{15}\text{O}^-$ |
| Charge /mass | 1/14              | 2/14 = 1/7           | 1/14              | 2/28 = 1/14           | 1/15              |

Since angle of deflection is charge/mass ratio, **S** and **T** have roughly the same angle of deflection but different polarity, while **U** has almost double the angle of deflection as **T**.

- 2 An element **L** can exist in a few oxidation states. 0.1 mol of  $\text{L}^{2+}$  requires 0.04 mol of acidified  $\text{KMnO}_4$  for complete reaction.

The half equation for reduction of  $\text{MnO}_4^-$  is



What is the final oxidation state of **L**?

- A** +4                      **B** +3                      **C** 0                      **D** -1

0.1 mol of  $\text{L}^{2+}$  loses  $0.04(5) = 0.20$  mol of electrons.  
 Imply 1 mol of  $\text{L}^{2+}$  loses 2 mol of electrons.

Oxidation state of **L** increases from + 2 to +4.

- 3 Use of Data Booklet is relevant to this question.

Nickel makes up 20% of the total mass of a coin. The coin has a mass of 10.0 g.

How many nickel atoms are in the coin?

- A**  $2.05 \times 10^{22}$       **B**  $4.30 \times 10^{22}$       **C**  $1.03 \times 10^{23}$       **D**  $1.20 \times 10^{24}$

2.0 g Ni = 0.03407 mol of Ni

No. of Ni atoms =  $0.03407(6.02 \times 10^{23}) = 2.05 \times 10^{22}$

- 4 Which compound has an unpaired electron in its structure?

- A**  $N_2O_4$       **B**  $BCl_3$       **C** NO      **D**  $NP_3$

- 2 In which sequence is the molecules listed in the order of increasing dipole moment?

- A**  $CF_4, CO, HF$

$CF_4$  is non-polar, dipole moments cancel out due to tetrahedral shape of molecule.

CO and HF are linear. HF is more polar than CO, as electronegativity difference is greater between H and F than between C and O.

- B**  $H_2O, H_2S, HBr$

$H_2O$  and  $H_2S$  have bent shape.  **$H_2O$  is more polar than  $H_2S$**  as O is more electronegative than S.

- C**  $SO_3, CO_2, AlCl_3$

All non-polar. Dipole moments cancel out due to shape of molecule.

- D**  $NH_3, HF, BeCl_2$

$NH_3$  and HF are polar but  $BeCl_2$  is non-polar, dipole moments cancel out due to linear shape of molecule.

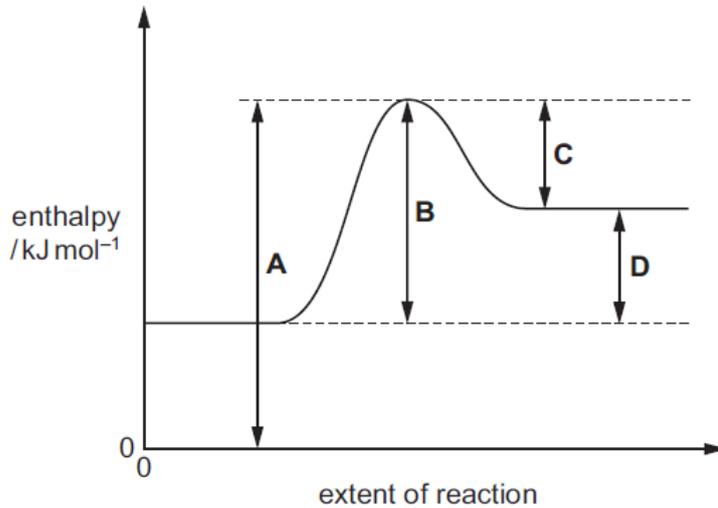
- 6 The  $C_2H_2$  molecule is linear.

What can be deduced from this about the numbers of  $\sigma$  and  $\pi$  bonds present in the molecule?

- |          | $\sigma$ | $\pi$ |
|----------|----------|-------|
| <b>A</b> | 2        | 2     |
| <b>B</b> | 2        | 3     |
| <b>C</b> | 3        | 1     |
| <b>D</b> | 3        | 2     |

$C_2H_2$  has structure  $H-C \equiv C-H$ .

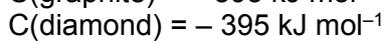
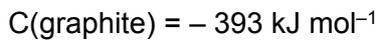
- 7 The diagram shows a reaction pathway for an endothermic reaction.



Which arrow represents the activation energy for the forward reaction?

**B is activation energy for the forward reaction. C is activation energy for the backward reaction.**

- 8 The standard enthalpy changes of combustion of carbon are as follows.



Which deductions can be made from the data above?

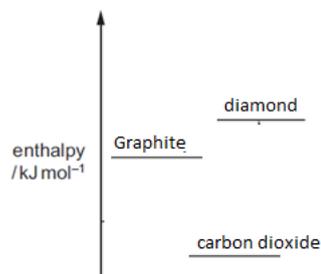
- 1 Graphite is more stable than diamond.
- 2 Graphite has a higher energy content than diamond.
- 3 Graphite is formed endothermically from diamond.

**A** 1, 2 and 3

**B** 2, and 3

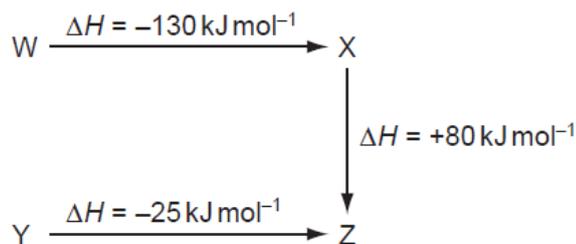
**C** 1 and 3 only

**D** 1 only



**From diagram, graphite is more stable than diamond, i.e. lower energy content from diamond and is formed exothermically from diamond.**

- 9 The diagram represents the energy changes for some reactions.

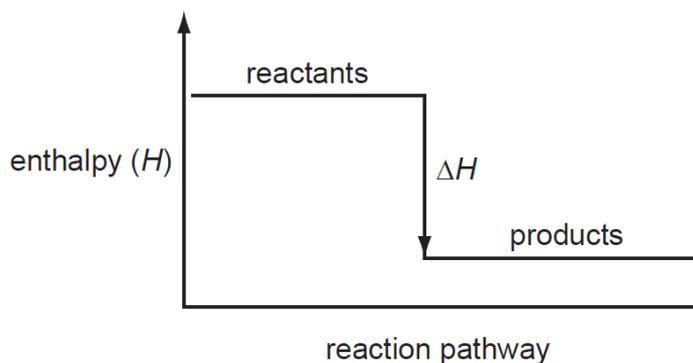


What are the natures of the conversions  $W \rightarrow Y$ ,  $Y \rightarrow X$  and  $Z \rightarrow W$ ?

|          | $W \rightarrow Y$ | $Y \rightarrow X$ | $Z \rightarrow W$ |
|----------|-------------------|-------------------|-------------------|
| A        | exothermic        | endothermic       | endothermic       |
| <b>B</b> | exothermic        | exothermic        | endothermic       |
| C        | endothermic       | exothermic        | exothermic        |
| D        | endothermic       | endothermic       | exothermic        |

|  | $W \rightarrow Y$           | $Y \rightarrow X$      | $Z \rightarrow W$      |
|--|-----------------------------|------------------------|------------------------|
|  | $-130 + 80 + 25$<br>$= -25$ | $-25 - 80$<br>$= -105$ | $-80 + 130$<br>$= +50$ |

- 10 Which enthalpy change could **not** be correctly represented by the enthalpy diagram shown?



- A standard enthalpy change of atomisation  
 B standard enthalpy change of combustion  
 C standard enthalpy change of hydration  
 D standard enthalpy change of neutralisation

Atomisation is endothermic (breaking of bonds to form gaseous atoms), while combustion, hydration and neutralisation are exothermic.



**C** rate =  $k[Y]^2[Z]$

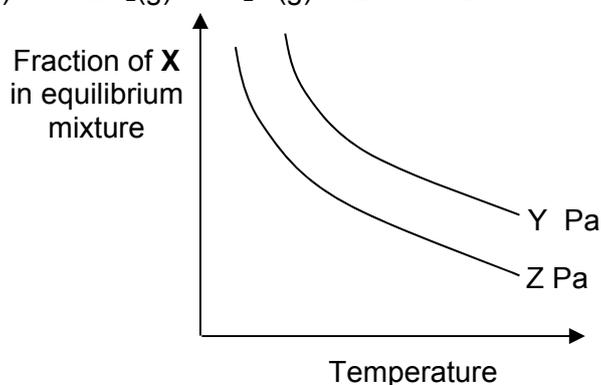
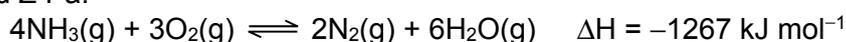
**D** rate =  $k[X][Y][Z]$

From the  $[X]$  versus time graph, a straight line indicates that the rate is constant with respect to any changes in  $[X]$ . Therefore order of reaction with respect to  $X$  is zero.

From the  $[Z]$  versus time graph, a constant half-time is obtained which indicates that the reaction is first order with respect to  $Z$ .

From the  $[Z]$  versus time graph, the time taken when  $[Y] = 2.0 \text{ mol dm}^{-3}$  is  $\frac{1}{4}$  of the time taken when  $[Y] = 1.0 \text{ mol dm}^{-3}$  for  $[Z]$  to drop from  $0.08 \text{ mol dm}^{-3}$  to  $0.04 \text{ mol dm}^{-3}$ .  
Therefore order of reaction with respect to  $Y$  is 2.

- 13** The graph below shows how the fraction of  $X$ , which represents one of the following compounds in the given equilibrium mixture, varies with temperature at pressures of  $Y \text{ Pa}$  and  $Z \text{ Pa}$ .



Identify  $X$  and the correct relative magnitudes of  $Y$  and  $Z$ .

|          | <b>X</b>             | <b>Pressure</b> |
|----------|----------------------|-----------------|
| <b>A</b> | $\text{N}_2$         | $Z > Y$         |
| <b>B</b> | $\text{O}_2$         | $Y > Z$         |
| <b>C</b> | $\text{H}_2\text{O}$ | $Y > Z$         |
| <b>D</b> | $\text{NH}_3$        | $Z > Y$         |

**Shape of graph:**

- As temperature increase, fraction of  $X$  decrease.
- As temperature increase, as forward reaction is exothermic, eqm shifts left to partially absorb some heat. Fraction of product should decrease.

Matching (i) and (ii):  $X$  should be the product of the reaction  $\Rightarrow$  either  $\text{N}_2$  or  $\text{H}_2\text{O}$ .

**Comparison of the two graphs:**

- From eqm equation: 7 mol of gaseous reactants vs 8 mol of gaseous products  $\Rightarrow$  decrease pressure will favour the forward reaction, to partially increase pressure.
- Decrease pressure increase the fraction of  $X$  (since  $X$  is the product)

Matching (i) and (ii): Fraction of  $X$  is higher for  $Y \text{ Pa}$  than  $Z \text{ Pa}$  ( $Y \text{ Pa} < Z \text{ Pa}$ )

- 14 One of the key production stages in the Contact Process is the production of sulfur trioxide.



The rate constants of the forward and backward reactions are given as  $k_1$  and  $k_{-1}$  respectively.

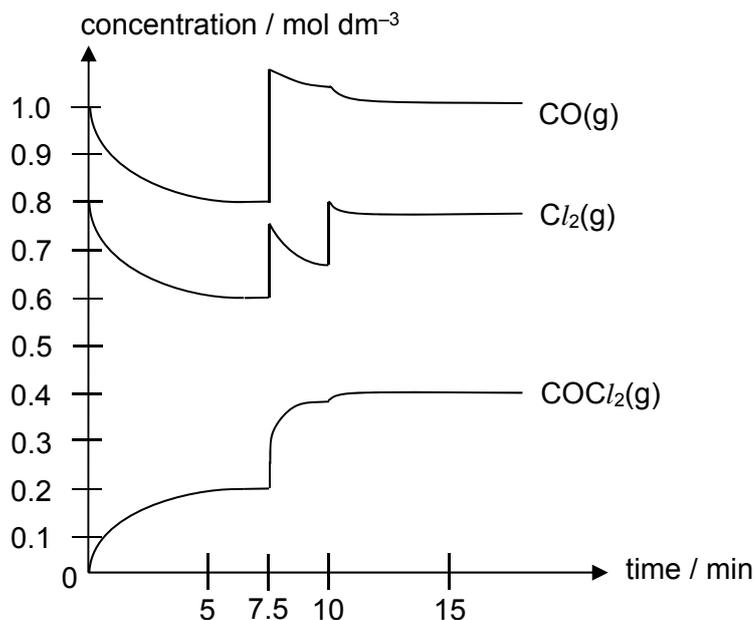
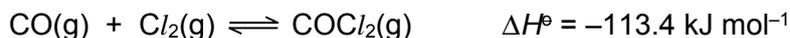
What happens to  $k_1$ ,  $k_{-1}$  and  $K_c$  if the temperature of the reaction is increased?

|          | $k_1$    | $k_{-1}$ | $K_c$    |
|----------|----------|----------|----------|
| <b>A</b> | increase | increase | increase |
| <b>B</b> | increase | decrease | increase |
| <b>C</b> | decrease | increase | decrease |
| <b>D</b> | increase | increase | decrease |

When temperature increases, no of molecules with energy greater than activation energy increases, frequency of effective collisions increases, **rates of reaction for forward and backward reactions increase. Rate constant for forward and backward reactions increase.**  $k_1$  and  $k_{-1}$  increase.

As reaction is exothermic, as temperature increases, equilibrium shifts backward to partially absorb the excess heat. Hence,  $K_c$  decreases as  $[\text{product}]/[\text{reactant}]$  decrease.

- 15 The reaction between carbon monoxide and chlorine was studied in an experiment by mixing the two gases and changing the reaction conditions inside the reaction vessel at different times during the experiment. The concentrations of the gases in the vessel were followed with time, and the following graph is obtained.



Which conclusion deduced from the graph is **incorrect**?

A The rate of forward reaction equals the rate of backward reaction at 7 min.

**Correct:** At 7 min, the system is in dynamic equilibrium (illustrated by constant concentrations/ plateaus) and hence the rate of forward reaction is equal to the rate of backward reaction.

B The change in concentration from 7.5 min to 10 min was produced by an increase in volume at constant temperature.

**Incorrect:** Increase in volume at constant temperature will cause all concentrations to decrease instantaneously, not increased.

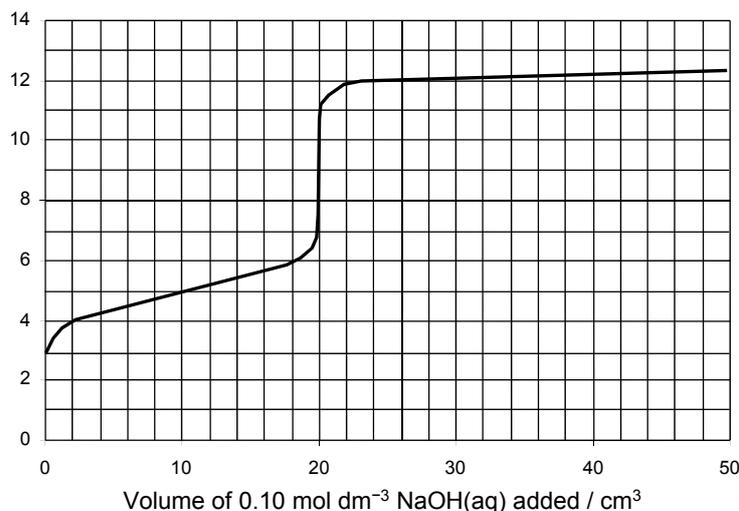
C The equilibrium constant,  $K_c$ , for the system when determined at 7 min is  $0.417 \text{ mol}^{-1} \text{ dm}^3$ .

**Correct:** Using  $K_c = \frac{[\text{COCl}_2]}{[\text{CO}][\text{Cl}_2]}$  and calculate.

D The change in concentration from 10 min to 15 min was produced by the addition of more chlorine.

**Correct:** When chlorine is added, the concentration of chlorine increases instantaneously as shown in the graph and then eqm shifts forward to partially reduce some chlorine.

16 The titration curve below shows the reaction between  $20.0 \text{ cm}^3$  of **HX**, and aqueous sodium hydroxide.



Given the following data:

| Indicator        | Colour change (acidic to basic medium) | pH range in which colour change occurs |
|------------------|--|--|
| Methyl red       | red to yellow                          | 4.2 – 6.3                              |
| Bromothymol blue | yellow to blue                         | 6.0 – 7.6                              |
| Thymolphthalein  | colourless to blue                     | 8.3 – 10.5                             |

What statements are correct?

1 Methyl red is the most suitable indicator to be used for this titration.

Incorrect. Equivalence point occurs around pH 9 which coincides/falls within working pH range of thymolphthalein. Thymolphthalein is the most suitable indicator, not methyl red.

2 Initial concentration of HX is  $0.10 \text{ mol dm}^{-3}$ .  
Correct.  $20.0 \text{ cm}^3$  of HX requires  $20.0 \text{ cm}^3$  of  $0.10 \text{ mol dm}^{-3}$  NaOH(aq) for complete neutralisation. Hence initial concentration of HX is  $0.10 \text{ mol dm}^{-3}$ .

3 When  $10.0 \text{ cm}^3$  of NaOH is added,  $[\text{H}^+]$  in the mixture is  $1.00 \times 10^{-5} \text{ mol dm}^{-3}$ .

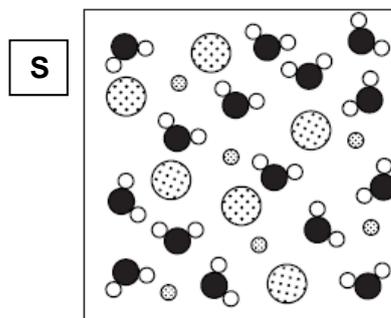
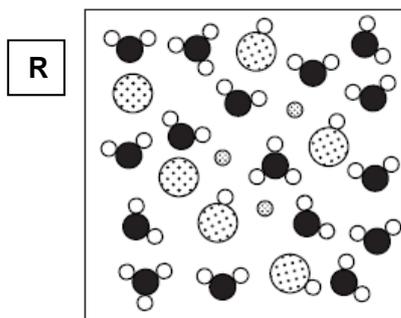
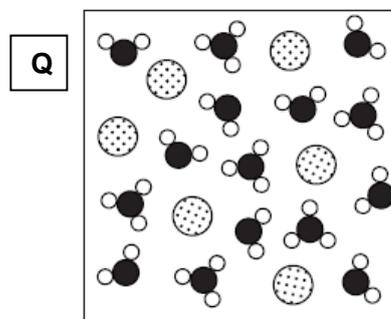
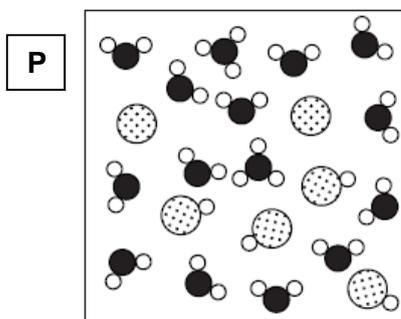
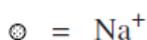
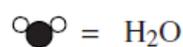
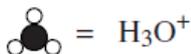
When  $10.0 \text{ cm}^3$  of  $0.10 \text{ mol dm}^{-3}$  NaOH(aq) is added,  $\text{pH} = 5$  from graph.

$$\text{pH} = -\lg [\text{H}^+] = 5$$

$$[\text{H}^+] = 1.00 \times 10^{-5} \text{ mol dm}^{-3}$$

A 1, 2 and 3      **B 2, and 3**      C 1 and 3 only      D 3 only

17 The diagrams represent some dilute aqueous solutions.  
In all cases, only a few of the large numbers of water molecules are shown.

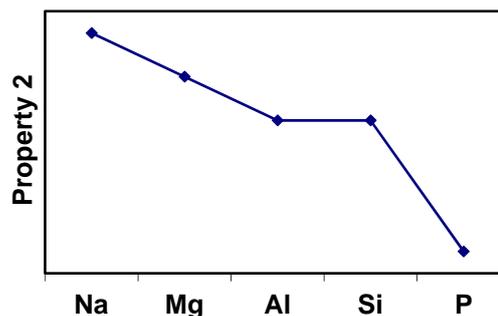
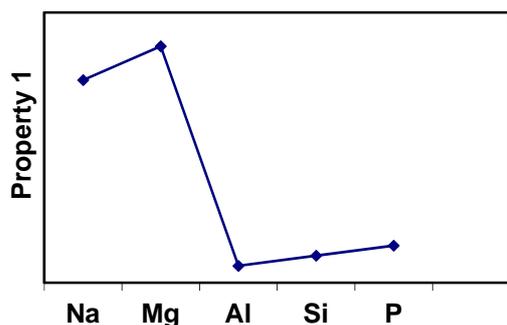


Which option correctly describes the solutions represented by the diagrams?

|   | P             | Q           | R   | S   |
|---|---------------|-------------|---|---|
| A | a strong acid | a weak acid | a salt formed by neutralising a strong acid with sodium hydroxide | weak acid partially neutralised by sodium hydroxide |

|          |  |  |   |   |
|----------|--|--|---|---|
| <b>B</b> | a weak acid  | a strong acid  | a salt formed by neutralising a strong acid with sodium hydroxide   | weak acid partially neutralised by sodium hydroxide   |
| <b>C</b> | a strong acid  | a weak acid  | weak acid partially neutralised by sodium hydroxide   | a salt formed by neutralising a strong acid with sodium hydroxide   |
| <b>D</b> | a weak acid  | a strong acid  | weak acid partially neutralised by sodium hydroxide   | a salt formed by neutralising a strong acid with sodium hydroxide   |
|          | Partial dissociation: mixture of HX, X <sup>-</sup> , H <sub>3</sub> O <sup>+</sup> , H <sub>2</sub> O | Full dissociation of HX: mixture of X <sup>-</sup> and H <sub>3</sub> O <sup>+</sup> | weak acid partially neutralised, ie. HX and NaX present. mixture of HX, X <sup>-</sup> , Na <sup>+</sup> , H <sub>2</sub> O | Salt from strong acid with NaOH. Hence only salt NaX and water present: X <sup>-</sup> , Na <sup>+</sup> , H <sub>2</sub> O |

- 18 The graphs below show the variation of two properties of some period 3 elements and/or their compounds.



Which correctly describes properties 1 and 2?

**Property 1**

**Property 2**

- |          |  |   |
|----------|--|---|
| <b>A</b> | atomic radius of the elements                          | electrical conductivity of the elements                         |
| <b>B</b> | boiling point of the highest oxidation state chlorides | pH of the highest oxidation state oxides when added to water    |
| <b>C</b> | melting point of oxides                                | first ionisation energies of the elements                       |
| <b>D</b> | electrical conductivity of elements                    | pH of the highest oxidation state chlorides when added to water |

| Property 1   | Property 2   |
|--|--|
| <p><b>For option A</b></p> <p>Atomic radii is a continuous decrease across the period. There is an increase in nuclear attraction for the outermost electrons because of increase in nuclear charge but constant shielding</p> | <p>Electrical conductivity increases from Mg to Al due to increase in no. of mobile charged carriers (more electrons in the sea of delocalised electrons).</p> <p>Electrical conductivity is very low for Si while P exhibit zero electrical conductivity.</p> |

|  |  |
|--|--|
| <p>caused by the same number of inner electrons.</p> <p>Hence graph cannot be atomic radii.</p>  | <p>Hence graph cannot be electrical conductivity.</p>  |
| <p><b>For option B</b><br/>Boiling points of chloride compounds decrease from NaCl to <math>\text{AlCl}_3</math>.<br/>Less energy is required to overcome the weak temporary dipole induced dipole interactions between <math>\text{AlCl}_3</math> molecules compared to the strong ionic bonds in giant ionic lattice of NaCl and <math>\text{MgCl}_2</math>.</p> <p><math>\text{AlCl}_3</math> to <math>\text{PCl}_5</math> are simple covalent molecules with Mr of <math>\text{AlCl}_3</math> (133.5) &lt; <math>\text{SiCl}_4</math> (170.1) &lt; <math>\text{PCl}_5</math> (208.5). B.pt increases with increasing ease of distortion of the electron clouds of the chloride compound, tdd interactions increase.</p> <p>Hence graph shows the correct trend in the b.pt of chlorides across period 3 element.</p> | <p><b>Acid base property of oxide depends on the nature of bonds present in the oxide.</b></p> <p>Ionic oxides tend to be basic and covalent oxides are usually acidic; ionic oxides with significant covalent character are amphoteric, this is usually observed when cation has high charge/size ratio.</p> <p><b>pH of oxides in aqueous medium depends on the nature of the bonds and solubility.</b></p> <p><math>\text{Na}_2\text{O}</math> is <b>basic and fully soluble</b> in water, therefore pH is very high (highly alkaline).<br/>Solubility of <math>\text{MgO}</math> is less than <math>\text{Na}_2\text{O}</math> but more soluble than <math>\text{Al}_2\text{O}_3</math>, hence pH of <math>\text{MgO}</math> &gt; <math>\text{Al}_2\text{O}_3</math>.</p> <p><math>\text{Al}_2\text{O}_3</math> is an amphoteric oxide while <math>\text{SiO}_2</math> is an acidic oxide.<br/><b>pH of <math>\text{Al}_2\text{O}_3</math> and <math>\text{SiO}_2</math> are 7 because both are insoluble in water.</b></p> <p>Oxides of P dissolve in water to give phosphoric acid, therefore pH is very low.</p> <p>Hence graph shows the correct trend for pH of aqueous oxides across period 3.</p> |
| <p><b>For option C</b><br/>Melting points of oxides across the period peak at <math>\text{SiO}_2</math> since <math>\text{SiO}_2</math> has a very strong giant covalent lattice. Phosphoric oxide is a simple covalent molecule, therefore drastic drop of m.pt from <math>\text{SiO}_2</math> to <math>\text{P}_4\text{O}_{10}</math>.<br/>Hence graph cannot be m.pt of oxides across period 3 elements.</p>  | <p>First ionisation energy of elements across period has a general increasing trend.<br/>There is an increase in nuclear attraction for the most loosely held electron because of increase in nuclear charge but constant shielding caused by the same number of inner electrons.</p> <p>Hence graph cannot be first ionisation energy.</p>  |
| <p><b>For option D</b><br/>Electrical conductivity increases from Mg to Al due to increase in no. of mobile charged carriers (more electrons in the sea of delocalised electrons).<br/>Electrical conductivity is very low for Si while P exhibit zero electrical conductivity.</p> <p>Hence graph cannot be electrical conductivity.</p>  | <p>Chlorides across period 3 are all soluble in aqueous medium. For chlorides that dissociates into ions in aq medium, cation hydrolysis gives rise to acidic solution. Extent of cation hydrolysis increases with charge/size ratio of the cation. Hence <math>\text{AlCl}_3</math> (aq) is more acidic than <math>\text{MgCl}_2</math>(aq) while NaCl is neutral (pH =7)</p> <p>Covalent chlorides react with water to form HCl, therefore the pH value is low for both <math>\text{SiCl}_4</math> and <math>\text{PCl}_5</math>.</p> <p>Hence graph cannot be pH trend of aqueous chlorides across the period.</p>  |

- 19 Element **H** is in Period 3 of the Periodic Table. The following four statements were made about the properties of element **J** or its compounds.

Three statements are correct descriptions and one is false.

Which statement does **not** fit with the other three?

- A** Adding NaOH(aq) to the solution resulting from the reaction of a chloride of **J** with water produces a white precipitate which is soluble in an excess of NaOH(aq).

From Data Booklet, cation that gives white precipitate with NaOH and soluble in an excess of NaOH(aq) is  $\text{Al}^{3+}$  and  $\text{Zn}^{2+}$ . Only  $\text{Al}^{3+}$  is in period 3.

- B** Element **H** is a solid at room temperature.

can be Na, Mg, Al, Si,  $\text{S}_8$ ,  $\text{P}_4$  from Period 3.

- C** Element **H** has the highest melting point among the period 3 elements.

must be Si if highest melting point.

- D** The oxide of element **H** is soluble in hydrochloric acid.

$\text{Al}_2\text{O}_3$  reacts with acid, hence is soluble in acid.  $\text{SiO}_2$  is not soluble in HCl.  $\text{SiO}_2$  is acidic, no reaction with HCl,

- 20 **J**, **K** and **L** are elements in Period 3 of the Periodic Table.

A mixture containing the oxides of **J**, **K** and **L** was dissolved in excess dilute sulfuric acid and filtered. The oxide of **L** was collected as a residue. When excess dilute sodium hydroxide was added to the filtrate, only a white precipitate of the hydroxide of **K** was formed.

What are the possible identities of **J**, **K** and **L**?

|          | <b>J</b> | <b>K</b> | <b>L</b> |
|----------|----------|----------|----------|
| <b>A</b> | Mg       | Al       | P        |
| <b>B</b> | Al       | Mg       | P        |
| <b>C</b> | Mg       | Al       | Si       |
| <b>D</b> | Al       | Mg       | Si       |

**L**:  $\text{SiO}_2$  is not soluble in HCl.  $\text{SiO}_2$  is acidic, no reaction with HCl.

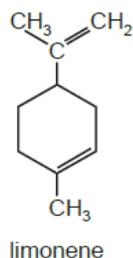
**J**:  $\text{Al}^{3+}$  gives white precipitate with NaOH and soluble in an excess of NaOH(aq).

**K**:  $\text{Mg}^{2+}$  gives white precipitate with NaOH and insoluble in an excess of NaOH(aq).

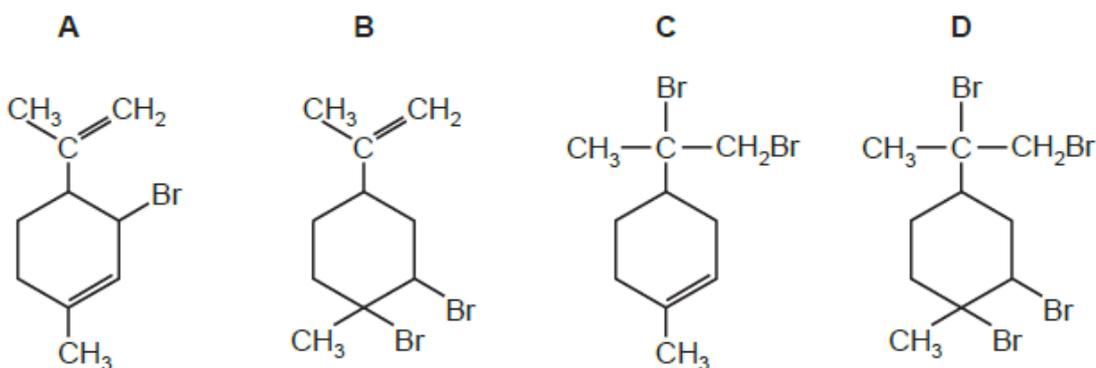
- 21 Which are the principal factors which cause the properties of nanomaterials to differ



- 25 Limonene is an oil formed in the peel of citrus fruits.



Which product is formed when an excess of bromine,  $\text{Br}_2(\text{l})$  reacts with limonene at room temperature in the dark?



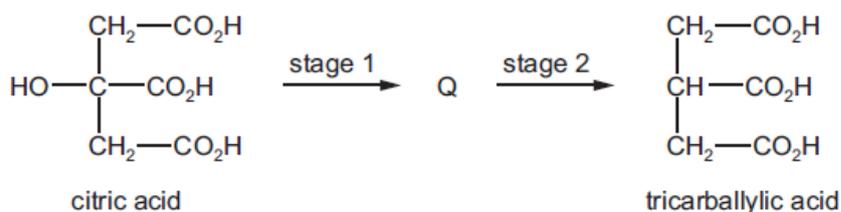
Answer: D. Bromine adds across both C=C bonds.

- 26 Which compound is a product of the hydrolysis of  $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{CH}_3$  by boiling aqueous sodium hydroxide?

**A**  $\text{CH}_3\text{OH}$       **B**  $\text{C}_3\text{H}_7\text{OH}$       **C**  $\text{C}_3\text{H}_7\text{CO}_2\text{H}$       **D**  $\text{C}_3\text{H}_7\text{CO}_2^-\text{Na}^+$



- 27 Citric acid can be converted into tricarballylic acid in two stages. An intermediate, Q, is formed.

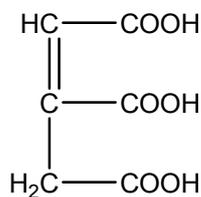


Which reagents are needed for each stage?

stage 1
stage 2

**A** Concentrated  $\text{H}_2\text{SO}_4$        $\text{H}_2(\text{g})$  and Ni

- |   |                                     |
|---|-------------------------------------|
| B Concentrated H <sub>2</sub> SO <sub>4</sub> | LiAlH <sub>4</sub>                  |
| C LiAlH <sub>4</sub>                          | H <sub>2</sub> SO <sub>4</sub> (aq) |
| D NaOH(aq)                                    | H <sub>2</sub> (g) and Ni           |



Q

Stage 1 is elimination of water, ie. Excess concentrated H<sub>2</sub>SO<sub>4</sub> , heat

Stage 2 is reduction of C=C bond. You can only use H<sub>2</sub>(g) and Ni, heat.

If LiAlH<sub>4</sub>, dry ether is used, C=C bond is not reduced while COOH group is reduced instead.

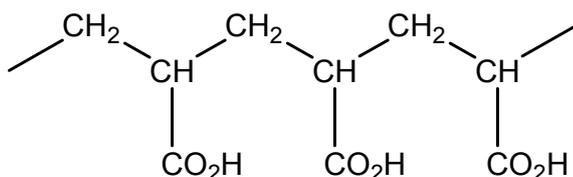
28 Which statements are correct for monomers and polymers involved in addition polymerization?

- 1 The monomers contain at least one unsaturated bond.
  - 2 Empirical formula of the addition polymer is the same as that of its monomer.
  - 3 Poly(vinyl alcohol) is formed via addition polymerization and can form hydrogen bonds between its adjacent molecules.
  - 4 Low density poly(ethene) (LDPE) and high density poly(ethene) (HDPE) are addition polymers but differ in their monomers.
- A All correct.
- B 1, 2 and 3
- C 1 and 2
- D 1, 2 and 4

Statements 1-3 are true.

Statement 4: LDPE and HDPE are addition polymers of ethene.

- 29 The absorbent material in babies' disposable nappies is made from the polymer



From which monomer could this polymer be obtained?

- A  $\text{C}/\text{CH}_2\text{CH}_2\text{CO}_2\text{H}$   
 B  $\text{HOCH}_2\text{CH}_2\text{CO}_2\text{H}$   
**C  $\text{H}_2\text{C}=\text{CHCO}_2\text{H}$**   
 D  $\text{HO}_2\text{CCH}=\text{CHCO}_2\text{H}$

Above polymer is an addition polymer. Monomer contains  $\text{C}=\text{C}$  and a single  $\text{COOH}$  group.

- 30 Chlorofluorocarbons (CFCs) are commonly used as aerosols, propellants and refrigerants. However in the stratosphere, CFCs can damage the ozone layer through a radical chain reaction.

In which sequence are the following compounds listed in increasing order of their ability to destroy ozone?

- A  $\text{CHC}/\text{FCC}/\text{F}_2 < \text{CCl}_2\text{FCCl}_2\text{F} < \text{CHC}/\text{F}_2$   
 B  $\text{CCl}_2\text{FCCl}_2\text{F} < \text{CHC}/\text{F}_2 < \text{CHC}/\text{FCC}/\text{F}_2$   
 C  $\text{CHC}/\text{F}_2 < \text{CCl}_2\text{FCCl}_2\text{F} < \text{CHC}/\text{FCC}/\text{F}_2$   
**D  $\text{CHC}/\text{F}_2 < \text{CHC}/\text{FCC}/\text{F}_2 < \text{CCl}_2\text{FCCl}_2\text{F}$**

$\text{C}-\text{F}$  bond is much stronger than  $\text{C}-\text{Cl}$ ,  $\text{C}-\text{F}$  bond does not break easily to form  $\text{F}$  radicals  $\Rightarrow$  does not damage ozone layer.

All four options (A), (B), (C) and (D) comprise of molecules containing  $\text{C}-\text{F}$  and  $\text{C}-\text{Cl}$  bonds. The molecule with more  $\text{C}-\text{Cl}$  bonds will have higher ability to destroy ozone due to more  $\text{Cl}$  radicals produced. Hence, answer is (D).

END of PAPER

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