

NATIONAL JUNIOR COLLEGE

SH2 PRELIMINARY EXAMINATION

Higher 1

CANDIDATE
NAME

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SUBJECT
CLASS

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REGISTRATION
NUMBER

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CHEMISTRY

8872/01

Paper 1 Multiple Choice

Thursday 17 Sept 2015

Additional Materials: Multiple Choice Answer Sheet

50 minutes

Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Write your name, subject class and registration number on the Answer Sheet in the spaces provided and shade the appropriate boxes for your registration number.

There are **thirty** questions in 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 Answer Sheet.

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.

This paper consists of 10 printed pages including this cover page.

Section A

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.

Element **X** forms ion X^{2+} with 4 unpaired electrons.

What could be element **X**?

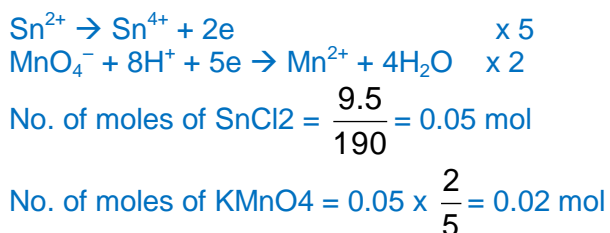
You'll need to do trial and error for this question by writing out the valence electronic configuration of X^{2+} for each option below.

- A** $Mg^{2+}: 2s^2 2p^6 \rightarrow$ no unpaired electrons
B $Cr^{2+}: 3d^4 \rightarrow$ 4 unpaired d electrons
C $Ti^{2+}: 4s^2 \rightarrow$ no unpaired electrons
D $Ni^{2+}: 3d^7 \rightarrow$ 3 unpaired d electrons

Answer: **B**

2. A solution of Sn^{2+} ions can reduce an acidified solution of MnO_4^- ions. The Sn^{2+} ions are oxidised to Sn^{4+} ions in this reaction.

How many moles of MnO_4^- ions are required to react completely with a solution containing 9.5 g of $SnCl_2$ ($M_r = 190$)?



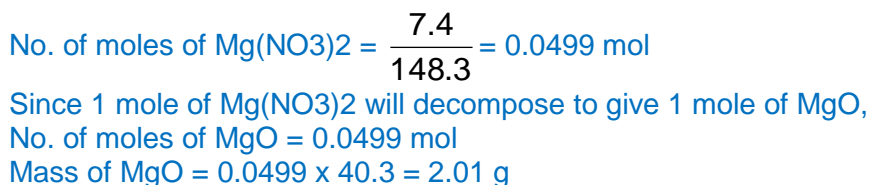
Answer: **B**

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

Magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated to give a white solid, MgO , and a mixture of gases. One of the gas is an oxide of nitrogen.

7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What is the mass of the white solid formed?



Answer: **B**

4. $AlCl_3$ vapour forms molecules with formula Al_2Cl_6 as it is cooled.

What happens to the bond angles during the change from $AlCl_3$ to Al_2Cl_6 ?

In $AlCl_3$, there are 3 bond pairs and 0 lone pairs around Al , the shape is trigonal planar about Al and bond angle is 120° .

In Al_2Cl_6 , there are 4 bond pairs and 0 lone pairs around Al , the shape is tetrahedral about Al and bond angle is 109.5° .

All the bond angles about Al decreases from 120° to 109.5° .

Answer: **C**

5. The table below shows the physical properties of four substances.

Which substance has a giant covalent structure?

	Melting point/ $^\circ C$	Boiling point/ $^\circ C$	Electrical conductivity of solid	Electrical conductivity of liquid	Electrical conductivity of aqueous solution
A	119	239	Good	Good	Insoluble
B	800	1210	Poor	Good	Good
C	993	1695	Poor	Poor	Good
D	1610	2230	Poor	Poor	Insoluble

We need to consider all the properties of substance with giant covalent structure.

Melting and boiling point: High (Eliminate option A)

Electrical conductivity in solid: Can be good (if it's graphite) or Poor (if it's diamond, Si, SiO_2)

Electrical Conductivity in liquid: Can be good (if it's graphite) or Poor (if it's diamond, Si, SiO_2).

Electrical conductivity in aqueous solution: Both diamond and graphite are not soluble in aqueous solution. (Eliminate option B and C)

Answer: **D**

6. What is the order of increasing melting point for the four chlorides shown?

	Lowest melting point \longrightarrow Highest melting point			
A	SiCl_4	PCl_5	MgCl_2	NaCl
B	PCl_5	SiCl_4	NaCl	MgCl_2
C	SiCl_4	PCl_5	NaCl	MgCl_2
D	NaCl	MgCl_2	SiCl_4	PCl_5

Both SiCl_4 and PCl_5 are simple covalent molecules and since both molecules are non-polar, the intermolecular forces between the molecules are temporary dipole-induced dipole interactions (TDID). The larger the M_r , the larger the electron cloud size which is more easily distorted and the TDID between PCl_5 is stronger than that in SiCl_4 and requires more energy to overcome.

Both NaCl and MgCl_2 are ionic compounds. The strength of ionic bond is determined

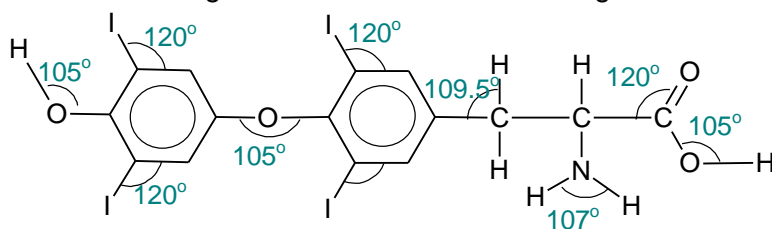
by the magnitude of lattice energy. $\text{LE} = \frac{q^+ q^-}{r^+ + r^-}$. Since Mg^{2+} has larger charge than

Na^+ , and ionic radius of Mg^{2+} is smaller than Na^{2+} and both compounds have the same anion, the LE of MgCl_2 is larger than NaCl and the ionic bond in MgCl_2 is stronger than NaCl which requires more energy to overcome.

The melting point increases from SiCl_4 to PCl_5 to NaCl to MgCl_2 .

Answer: **C**

7. Which bond angle is **not** found in the following molecule?



When considering the bond angles, you should not be fooled by the diagram drawn. You should consider all the bond pairs and lone pairs around the central atom to determine the shape.

There is no linear shape about any central atom therefore 180° is not possible.

Answer: **C**

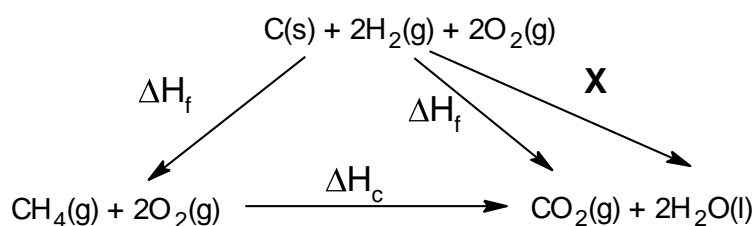
8. Which process is endothermic?

- A Condensation of steam
Energy is given out when steam changes to water and the process is exothermic.
- B Dissolving glucose in water
Dissolution can be endothermic or exothermic. In this case, the dissolution is endothermic and you may obtain this answer by eliminating other options.
- C Neutralization between strong acid and weak base
All neutralization reactions are exothermic.
- D Burning of charcoal
All combustions are exothermic.

Answer: B

9. Enthalpy changes that are difficult to measure directly can often be determined using Hess' Law to construct an enthalpy cycle.

Which enthalpy change is indicated by X in the enthalpy cycle shown?



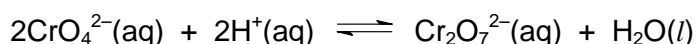
X represents either 2 x enthalpy change of combustion of hydrogen (eliminate options A and B).

or X represents 2 x enthalpy change of formation of water.

The + or – sign is indicating the direction of arrow. Since the **direction of arrow is in the direction of the definition, the sign of the arrow is positive**. (i.e. Enthalpy change of formation of water is the energy change when one mole of water is formed FROM its elements in their standard states.)

Answer: D

10. Which statement concerning the equilibrium reaction given below is correct?



A A redox reaction is taking place.

Incorrect because the oxidation state of Cr remains as +6 on both sides. You do not need to calculate the oxidation states of O and H because the oxidation of O is always -2 in all covalent and ionic compound except for elements O_2 and hydrogen peroxide H_2O_2 . The oxidation state of H in all covalent compounds is +1.

B The equilibrium constant, K_c , has no units.

Incorrect because for this equilibrium, $K_c = \frac{[\text{Cr}_2\text{O}_7^{2-}]}{[\text{CrO}_4^{2-}]^2[\text{H}^+]^2}$ and the unit is $\text{mol}^{-3} \text{dm}^9$

C A decrease in pH will result in an increase in the concentration of $\text{Cr}_2\text{O}_7^{2-}$.

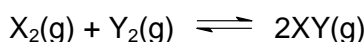
Correct because when pH decreases, $[\text{H}^+]$ increases and position of equilibrium shifts right to partially decrease $[\text{H}^+]$. Therefore, more $\text{Cr}_2\text{O}_7^{2-}$ will be formed.

D The addition of a catalyst will result in an increase in the concentration of $\text{Cr}_2\text{O}_7^{2-}$.

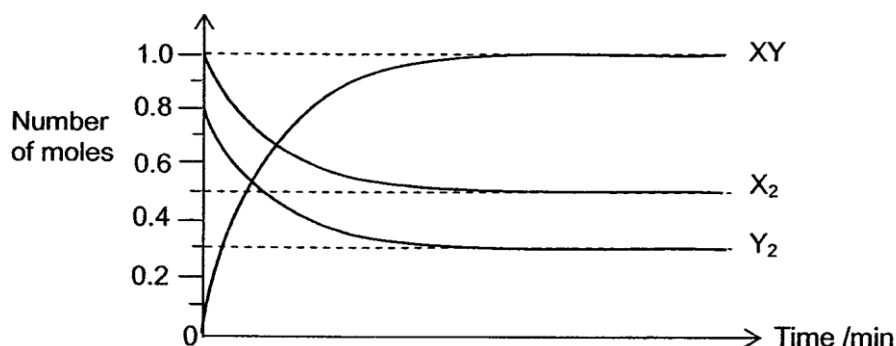
Incorrect because catalyst increases the rate of forward and backward reaction to the same extent. Therefore, the overall concentration of reactants and products will not increase.

Answer: **C**

11. The gases, X_2 and Y_2 react as follows,



A mixture containing 1.0 mol of X_2 and 0.8 mol of Y_2 is heated in a closed container and the reaction is allowed to reach equilibrium. The graph below shows the variation of the number of moles of each gas with time.



What is the numerical value of K_c ?

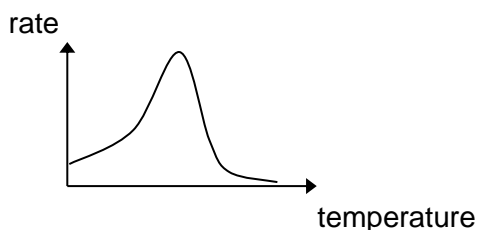
In order to determine the equilibrium concentration, you'll need to look at the number of moles of reactant and product when the graph becomes horizontal because that is when equilibrium is reached.

$$K_c = \frac{[\text{XY}]^2}{[\text{X}_2][\text{Y}_2]} = \frac{\left(\frac{1}{V}\right)^2}{\left(\frac{0.5}{V}\right)\left(\frac{0.3}{V}\right)} = 6.67$$

Answer: **C**

12. Which graph describes the kinetics of an enzyme-catalysed reaction against temperature?

As enzymes are biological molecules, at low temperature, enzyme is inactive and the rate of reaction is low. At high temperature, the enzyme is denatured and the rate of reaction reaches 0.



Answer: **C**

13. An experiment is conducted by reacting $\text{NO}_2(\text{g})$ with $\text{F}_2(\text{g})$. What is the order of reaction with respect to $\text{NO}_2(\text{g})$ and the overall order, given the following rate data at a certain temperature?

$[\text{NO}_2(\text{g})]/\text{mol dm}^{-3}$	$[\text{F}_2(\text{g})]/\text{mol dm}^{-3}$	Rate/ $\text{mol dm}^{-3} \text{min}^{-1}$
0.1	0.2	0.1
0.2	0.2	0.4
0.1	0.4	0.2

Comparing experiment 1 and 2,
When $[\text{NO}_2]$ x2, the rate x4, order wrt $[\text{NO}_2]$ is 2.

Comparing experiments 1 and 3,
When $[\text{F}_2]$ x 2, the rate x2, order wrt $[\text{F}_2]$ is 1.

Overall order of reaction = $2 + 1 = 3$

Answer: **D**

14. When equal volumes of hydrochloric acid solution of pH 1 and pH = 4 are mixed, what is the pH of the resultant mixture?

Let the volume of the acid solution be V .

The total no. of mole of $\text{H}^+ = 10^{-1} \times V + 10^{-4} \times V$

$$\text{Total } [\text{H}^+] = \frac{10^{-1}V \times 10^{-3}V}{2V} = 0.0505 \text{ mol dm}^{-3}$$

$$\text{pH} = -\log [\text{H}^+] = 1.30$$

Answer: **B**

15. Which pair of chemicals will produce an alkaline buffer?

In order to have an alkaline buffer, the solution must be made up of a weak base and its conjugate acid salt.

If the solution is made up of an acid and base, there will be acid base neutralization and you'll need to consider the composition of the resultant solution.

A 20 cm³ of 1 mol dm⁻³ of HCl and 20 cm³ of 0.5 mol dm⁻³ of NH₃
nHCl = 0.020 mol
nNH₃ = 0.010 mol
Resultant solution contains excess HCl and NH₄Cl salt → Strong acid solution

B 20 cm³ of 1 mol dm⁻³ of NH₃ and 20 cm³ of 0.5 mol dm⁻³ of HCl
nNH₃ = 0.020 mol
nHCl = 0.010 mol
Resultant solution contains NH₃ and NH₄Cl salt → Alkaline buffer

C 20 cm³ of 1 mol dm⁻³ of H₂SO₄ and 20 cm³ of 0.5 mol dm⁻³ of NH₃
nH₂SO₄ = 0.020 mol
nNH₃ = 0.010 mol
Resultant solution contains excess H₂SO₄ and (NH₄)₂SO₄ salt → Strong acid solution

D 20 cm³ of 1 mol dm⁻³ of NH₃ and 20 cm³ of 0.5 mol dm⁻³ of H₂SO₄
nNH₃ = 0.020 mol
nH₂SO₄ = 0.010 mol
Since 1 mole of H₂SO₄ requires 2 moles of NH₃ for complete reaction, all the NH₃ and H₂SO₄ reacts completely in stoichiometric ratio to produce (NH₄)₂SO₄ salt.
Resultant solution contains only (NH₄)₂SO₄ salt. → Weak acid solution

Answer: **B**

16. Which reagent, when mixed and heated with ammonium sulfate, liberates an alkaline gas?

In order for ammonium, NH₄⁺, which is a weak acid, to liberate a gas, NH₃, which is a weak base, an acid base reaction must occur. The species which react with NH₄⁺ must be a base.



Answer: **C**

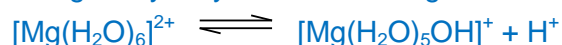
17. When water is added to 1 mole of chloride of **X**, 2 moles of HCl gas are given out as white fumes.

What could be the identity of the element?

In order to produce HCl , the chloride must be a covalent chloride. For covalent chlorides, in order to determine the number of moles of HCl gas produced, you'll need to recall the equations when the chloride dissolves in water.

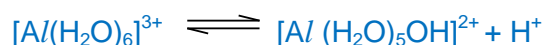
A Mg

MgCl_2 is an ionic chloride and it does not hydrolyse in water to give HCl gas even though it hydrolyses in water to give an acidic solution.



B Al

AlCl_3 is a covalent chloride. In excess water, it hydrolyses in water to give an acidic solution.



In limited water, AlCl_3 will give 3 moles of HCl (g).



C Si

SiCl_4 is a covalent chloride and will give 4 moles of HCl (g).



D P

P forms two possible covalent chlorides, PCl_3 and PCl_5 .

PCl_3 gives out 3 moles of HCl



PCl_5 gives out 5 moles of HCl in excess water.



PCl_5 gives out 2 moles of HCl in limited water.



Answer: **D**

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

Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?

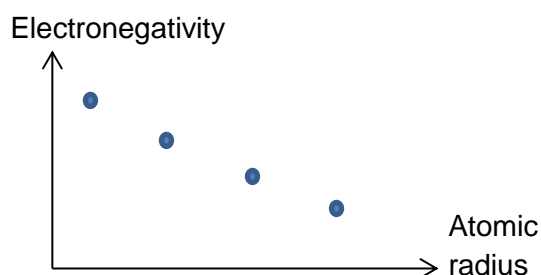
The relationship between Na, Mg, Al and Si is that they are across the same period.

Electronegativity increases across the period as nuclear charge increases due to increasing number of protons and shielding effect remains approximately the same due the same number of inner shell electrons. Therefore, nuclear attraction on valence electron increases and the ability of the atom to attract a shared pair of electron increases.

Atomic radius decreases across the period as nuclear charge increases due to increasing number of protons and shielding effect remains approximately the same due the same number of inner shell electrons. Therefore, nuclear attraction on valence electron increases and the distance between nucleus and valence electron decreases.

The trend in electronegativity and atomic radius are in opposite direction. When atomic radius increases, the electronegativity decreases.

B



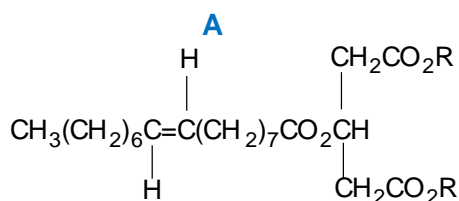
19. Some vegetable oils contain “trans fats” that are associated with undesirable increases in the amount of cholesterol in blood.

In the structures below, R is a hydrocarbon chain.

Which structure correctly illustrates a “trans fat”?

A trans fat has **2 same groups on opposite sides** (eliminate B) and **each C of C=C is bonded to 2 different groups** (eliminate C and D).

Note that $\text{CH}_3(\text{CH}_2)_6-$ is the same as $\text{CH}_3(\text{CH}_2)_5\text{CH}_2-$ and therefore D is not possible.



Answer: **A**

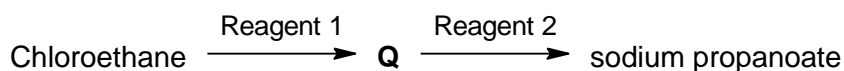
20. Many organic reactions need to be heated before any reaction occurs, but some do not require heating.

Which reaction occurs quickly at room temperature?

- A $\text{C}_2\text{H}_4 + \text{Br}_2 \longrightarrow \text{C}_2\text{H}_4\text{Br}_2$
Reagent and condition: Br_2 , CCl_4 , Room temperature
- B $\text{C}_2\text{H}_4 + \text{H}_2\text{O} \longrightarrow \text{CH}_3\text{CH}_2\text{OH}$
Condition: H_3PO_4 , 300 °C, 65 atm
- C $\text{CH}_3\text{CH}_2\text{OH} \longrightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O}$
Reagent and condition: Al_2O_3 , heat or excess con. H_2SO_4 , 170°C
- D $\text{CH}_3\text{CH}_2\text{OH} + \text{HBr} \longrightarrow \text{CH}_3\text{CH}_2\text{Br} + \text{H}_2\text{O}$
Condition: HBr , heat or con. H_2SO_4 , KBr , heat

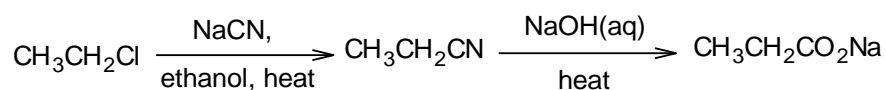
Answer: A

21. Chloroethane can be used to make sodium propanoate.



Which are the correct reagents for the above reaction?

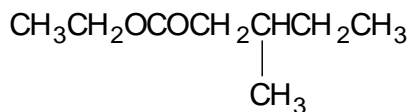
When there is an increase in number of carbon, one of the reagent used must be KCN (which reacts with RX) or HCN (which reacts with carbonyl).



Answer: B

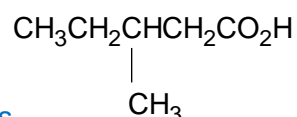
22. An ester with an odour of banana has the following formula.

Which pairs of reactants, under suitable conditions, will produce this ester?



Note that when the ester linkage is $-\text{COO}-$, it means that the ester is carboxylic acid-alcohol.

When the ester linkage is $-\text{OCO}-$, it means that the ester is alcohol-carboxylic acid.



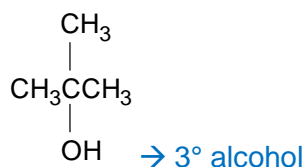
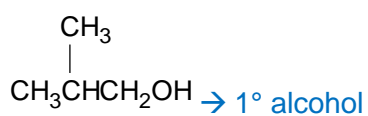
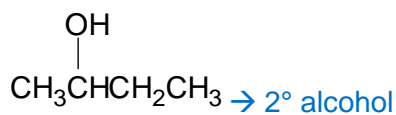
In this case, the alcohol is $\text{CH}_3\text{CH}_2\text{OH}$ and the carboxylic acid is

Answer: C

23. Considering all the structural isomers of alcohol with the molecular formula $\text{C}_4\text{H}_{10}\text{O}$, what is the number of each type of alcohol formed?

All the isomers of alcohols are:

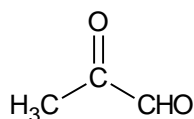
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \rightarrow 1^\circ$ alcohol



Total: two 1° alcohol, one 2° alcohol, one 3° alcohol

Answer: C

24. Burnt sugar has a characteristic smell caused partly by the following compound.



This compound contains two functional groups.

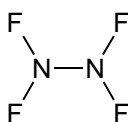
Which reagent will react with only one of the functional groups?

- A Alkaline copper(II) complex
Reacts with aldehyde.
- B PCl_5
Does not react with any functional group as PCl_5 reacts with $-\text{OH}$.
- C Hydrogen cyanide
Reacts with both aldehyde and ketone.
- D Sodium hydroxide
Does not react with any functional group as both aldehyde and ketone is neutral.

Answer: A

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

When the liquid N_2F_4 is heated, it decomposes into a single product, **X**.
Which statements are correct?



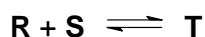
The structure of N_2F_4 is $\text{F}-\text{N}-\text{N}-\text{F}$. During decomposition, the molecule must break symmetrically in order to give a single product, **X**.

Therefore, $\text{N}_2\text{F}_4 \rightarrow \text{NF}_2 + \text{NF}_2$

- 1 N-F bonds are broken during this decomposition.
Incorrect because in order to product NF_2 , N-N bond is broken.
- 2 The enthalpy change when N_2F_4 decomposes into **X** is approximately $+160 \text{ kJ mol}^{-1}$.
Correct because during decomposition, N-N bond is broken and the bond energy N-N is $+160 \text{ kJ mol}^{-1}$.
- 3 Molecules of **X** are non-linear.
X is NF_2 and it has 2 bond pairs 2 lone pairs and the geometry is bent.

Answer: C (2 and 3 are correct)

26. **R** and **S** react to form **T** according to the equation shown below.

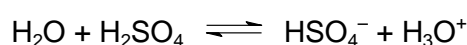
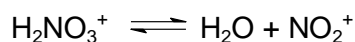
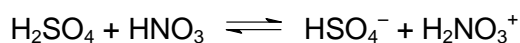


Which factors affect the rate of the forward reaction?

Rate of reaction is affected by temperature, pressure, concentration, surface area and catalyst only. Factors such as enthalpy change of reaction or K_c will not affect the rate.

Answer: **D** (1 Only)

27. When concentrated sulfuric acid and concentrated nitric acid are mixed, the following reactions occur.



Which species are conjugate bases in these reactions?

A conjugate acid-base pair is a pair of species which differs from each other by a H^+ . A conjugate base has 1 H^+ less from the other species.

- 1 HSO_4^- is a conjugate base as H_2SO_4 is its conjugate acid.
- 2 HNO_3 is a conjugate base as H_2NO_3^+ is its conjugate acid.
- 3 H_2O is a conjugate base as H_3O^+ is its conjugate acid.

Answer: **A** (1, 2 and 3)

28. Pollutant oxide **Y**, which contains non-metallic element **X**, is formed in a car engine.

Further oxidation of **Y** to **Z** occurs in the atmosphere. In this oxidation, 1 mol of **Y** reacts with 0.50 mol of gaseous oxygen molecules.

Possible identity of element **X** is nitrogen or sulfur.

Which statements about **X**, **Y** and **Z** can be correct?

Assuming that **X** is nitrogen, then **Y** is NO and **Z** is NO_2 .

- 1 The oxidation number of **X** increases by two from **Y** to **Z**.
Correct. From NO to NO_2 , the oxidation of N increases by 2 from +2 to +4.
- 2 **Y** has an unpaired electron in its molecule.
Correct. NO has an unpaired electron because the total no. of valence electron of $\text{N} + \text{O} = 5 + 6 = 11$ so there will be an odd number electron.
- 3 **Y** is a polar molecule.
Correct. NO is polar as N and O has different electronegativity.

Options 1,2 and 3 are correct.

Assuming that X is sulfur, the Y is SO₂ and Z is SO₃.

- 1 The oxidation number of X increases by two from Y to Z.
Correct. From SO to SO₃, the oxidation of S increases by 2 from +4 to +6.
- 2 Y has an unpaired electron in its molecule.
Incorrect. The total number of electron in S + 2O = 6 + 2x6 = 18. Therefore there will be no odd number electron and hence there will not be any unpaired electron.
- 3 Y is a polar molecule.
Correct. SO₂ is polar as S and O has different electronegativity and the shape of SO₂ is bent and there will be a net dipole moment.

Options 1 and 3 are correct and there is no such options.

Therefore, Element X must nitrogen.

Answer: A

29. The molecule responsible for the pineapple flavour used in sweets is CH₃CH₂CH₂CO₂CH₂CH₃.

Which statements about this molecule are correct?

- 1 The name of this compound is ethyl butanoate.
Correct. Since the ester linkage is –CO₂–, it is formed from carboxylic acid-alcohol. The carboxylic acid is butanoic acid and the alcohol is ethanol.
- 2 This compound is a structural isomer of hexanoic acid.
Correct. Since both hexanoic acid and ethyl butanoate have the same molecular formula of C₆H₁₂O₂.
- 3 When this compound is heated with aqueous sodium hydroxide, the products are butan-1-ol and ethanoic acid.
When an ester is heated with aqueous sodium hydroxide, there will be hydrolysis reaction to form carboxylic acid and alcohol. However, in alkaline medium, the carboxylic acid will be neutralised to form sodium ethanoate instead of remaining as ethanoic acid.

Answer: B (1 and 2 only)

30. Which statements about pentan-1,4-diol or its oxidation products are correct?

- 1** When one mole of pentan-1,4-diol reacts with an excess of sodium metal, one mole of hydrogen molecule is produced.

Correct because each alcohol will produce $\frac{1}{2}$ mole of hydrogen gas. Two alcohol will produce 1 mol of hydrogen gas.

- 2** At least one of the possible oxidation products of pentan-1,4-diol will react with 2,4-dinitrophenylhydrazine.

Correct because the condition of oxidation is not specify. If the alcohol is heated with distillation, the primary alcohol will become aldehyde which will react with 2,4-dinitrophenylhydrazine.

- 3** Dehydration of pentan-1,4-diol could produce a compound with empirical formula C_5H_8 .

Correct. Dehydration of alcohol forms alkene by removing a H_2O from adjacent carbons.



Answer: **A**