

2

Section A

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

- 1** 10 cm³ of a hydrocarbon was mixed with 100 cm³ of oxygen gas which was in excess. After explosion and cooling, the gaseous mixture occupied a volume of 80 cm³. After absorption by aqueous potassium hydroxide, the volume decreased to 50 cm³.

What is the formula of the unknown hydrocarbon?

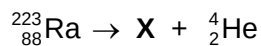
- A** C₃H₆
 - B** C₃H₈
 - C** C₄H₈
 - D** C₄H₁₀
- 2** Ethanenitrile, CH₃CN was boiled with NaOH and the NH₃ gas evolved was passed into 50 cm³ of 1.00 mol dm⁻³ of HCl. The excess acid required 26.00 cm³ of 1.00 mol dm⁻³ NaOH solution for complete neutralisation.

What was the mass of ethanenitrile used?

- A** 0.492 g
 - B** 0.984 g
 - C** 1.07 g
 - D** 1.97 g
- 3** For a given mass of an ideal gas, which one of the following graphs displays a different shape from the rest?
- A** PV against V (at constant T)
 - B** PV against P (at constant T)
 - C** $\frac{V}{T}$ against T (at constant P)
 - D** $\frac{1}{\text{density}}$ against T (at constant P)

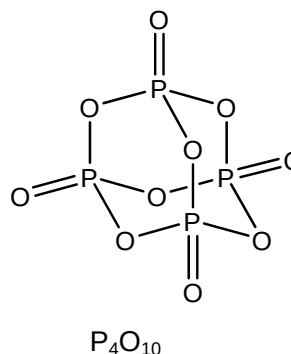
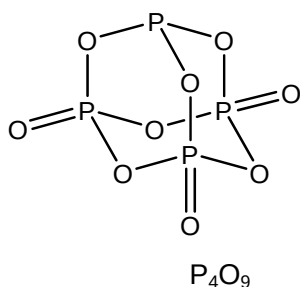
3

- 4 Xofigo®, containing the radioactive isotope, $^{223}_{88}\text{Ra}$, had received United States FDA approval for the treatment of cancer in patients. $^{223}_{88}\text{Ra}$ decays to give only an element **X** and a high energy α -particle (^4_2He); the latter targets the cancer cells.



What is the number of **neutrons** present in element **X**?

- A 86
B 133
C 135
D 219
- 5 Phosphorus oxides exist in many different intermediate forms.



Two forms of phosphorus oxides, P_4O_9 and P_4O_{10} , are shown above.

Which one of the following statements is **true**?

- A The phosphorus atoms of both oxides can act as ligands.
B The phosphorus atoms of both oxides have the same oxidation state.
C The phosphorus atoms of both oxides do not have lone pair of electrons
D The phosphorus atoms of both oxides have electron pairs that are arranged in tetrahedral shape.

4

6 Which statement about AlCl_3 is **correct**?

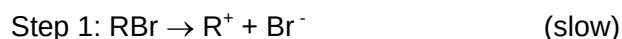
- A AlCl_3 is pyramidal.
- B AlCl_3 has a higher melting point than Al_2O_3 .
- C Al_2Cl_6 dimer contains two co-ordinate bonds.
- D AlCl_3 catalyst acts as an electron pair donor in the acylation of benzene.

7 Consider the equation: $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$
where $\Delta H = -199 \text{ kJ mol}^{-1}$ and $\Delta S = -190 \text{ J K}^{-1} \text{ mol}^{-1}$.

Which of the following statements is correct?

- A As the reaction proceeds, the system becomes more disorderly.
- B The products are energetically less stable than the reactants.
- C As temperature increases, the change in Gibbs free energy becomes more negative.
- D The reaction is spontaneous under standard conditions.

8 Consider the mechanism of the hydrolysis of 2-methyl-2-bromopropane (RBr) by hydroxide ion below:

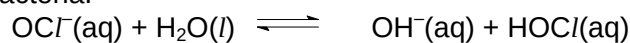


Which one of the following correctly represents the units for the rate constant of this reaction?

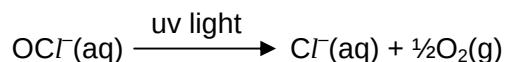
- A $\text{mol dm}^{-3} \text{ s}^{-1}$
- B $\text{mol}^{-1} \text{ dm}^3 \text{ s}$
- C $\text{mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$
- D s^{-1}

5

- 9 Swimming pool water can be kept free of harmful bacteria by adding aqueous sodium chlorate(I), NaOCl. This reacts with water to produce HOCl molecules which kill bacteria.



In bright sunshine, the OCl⁻ ion is broken down by ultra-violet light.



Which method would maintain the highest concentration of HOCl(aq)?

- A acidify the pool water
 - B add a solution of chloride ions
 - C add a solution of hydroxide ions
 - D bubble air through the water
- 10 To prepare 'deionised' water, tap water containing ions, including chloride ions, is passed through a column of resin that helps to remove the ions present.

If the concentration of chloride ions in the water that leaves the column is high enough to cause the precipitation of silver chloride when 1 cm³ of the water is added to 1 cm³ of 1 mol dm⁻³ silver nitrate solution, the water is no longer considered 'deionised' and hence, the resin in the column has to be replaced.

What is the maximum allowed concentration of chloride ions that can be present in the water that leaves the column?

[Solubility product of silver chloride : $1.8 \times 10^{-10} \text{ mol}^2 \text{ dm}^{-6}$]

- A $1.8 \times 10^{-10} \text{ mol dm}^{-3}$
- B $3.6 \times 10^{-10} \text{ mol dm}^{-3}$
- C $7.2 \times 10^{-10} \text{ mol dm}^{-3}$
- D $1.8 \times 10^{-11} \text{ mol dm}^{-3}$

6

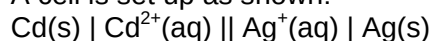
- 11** The pH range and colour changes for two acid-base indicators are given below:

Indicator	Colour in acidic solution	pH range	Colour in basic solution
P	violet	3.0-5.0	red
Q	yellow	5.7-7.6	blue

Which solution will appear red in **P** and yellow in **Q**?

- A** 0.1 mol dm⁻³ of HCl
- B** 0.1 mol dm⁻³ of NaOH
- C** 0.1 mol dm⁻³ of CH₃COOH ($K_a = 1.8 \times 10^{-5}$ mol dm⁻³)
- D** 0.1 mol dm⁻³ of HX ($K_a = 2.5 \times 10^{-10}$ mol dm⁻³)
- 12** *The use of Data Booklet is relevant to this question.*

A cell is set up as shown:



The following values for the cell potential were determined as a change was continuously made.

Readings	Cell potential/ V
1	1.200
2	1.081
3	1.064

Which one of the following changes was made?

- A** adding a reagent to the solution that complex with Ag⁺(aq)
- B** increasing concentration of Ag⁺(aq)
- C** increasing the surface area of the cadmium immersed in the solution
- D** adding equal amount of water to both half-cells

7

- 13 When a large current was passed through an electrolyte containing chromium(III) ions, there was a simultaneous liberation at the cathode, x mol of chromium and y dm³ of hydrogen (measured at r.t.p.).

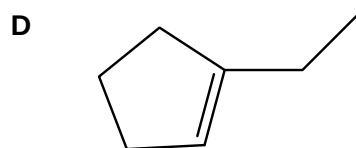
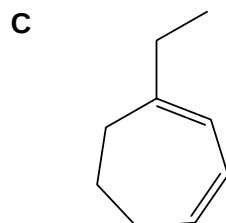
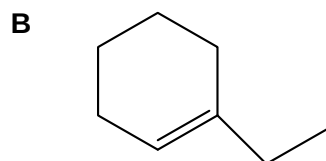
How many moles of electrons were passed through the solution?

- A $x + y$
 B $x + y/24$
 C $3x + y/24$
 D $3x + y/12$

- 14 A hydrocarbon, when heated with excess hot acidified concentrated KMnO_4 produces $\text{HO}_2\text{CCH}_2\text{CH}_2\text{CH}_2\text{COCH}_2\text{CH}_3$.

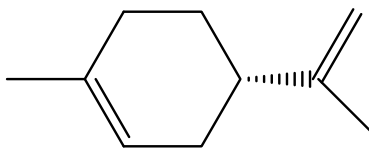
Which one of the structures **cannot** be the hydrocarbon?

- A $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{CH}_2\text{C}(\text{CH}_2\text{CH}_3)=\text{CH}_2$



8

- 15 Limonene, a main odour constituent of citrus fruits, is added to cleaning products such as hand cleansers to give a lemon-orange fragrance.



Which of the following about limonene is **correct**?

- A It exhibits cis and trans isomerism.
- B It reacts with acidified concentrated $K_2Cr_2O_7$ to give a colourless and odourless gas.
- C It reacts with H_2 in nickel to form an alkane with formula C_9H_{18} .
- D It reacts with Br_2 in organic solvent to form a product with 4 chiral carbons.
- 16 Compound **R** is heated in a sealed tube with ammonia, whereas compound **S** is reacted with hydrogen in the presence of catalyst. Both reactions give the same product.

Which are the structures of **R** and **S**?

	R	S
A	C_6H_5Br	C_6H_5CN
B	$CH_3CH(Br)CH_3$	$CH_3CH(CN)CH_3$
C	$CH_3CH_2CH_2Br$	CH_3CH_2CN
D	$CH_3CH(Br)CH_3$	CH_3CH_2CN

9

- 17 **T**, **U** and **V** are three different 4-carbon compounds. **T** and **U** react together to form an ester. **V** reacts with **T** to give the same ester but much less readily when compared to **U**.

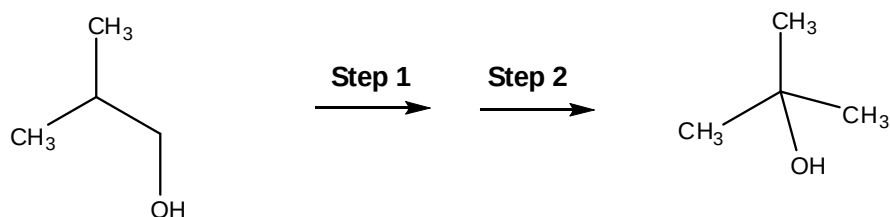
Which of the following could be **T**?

- A** butanoic acid
B butanone
C butan-2-ol
D butanoyl chloride

- 18 Which sequence shows the correct order of **decreasing** ease of hydrolysis?

- A** $\text{CH}_3\text{CH}_2\text{COCl} > \text{CH}_3\text{CH}_2\text{Cl} > \text{CH}_2=\text{CHCl}$
B $\text{CH}_3\text{CH}_2\text{Cl} > \text{CH}_3\text{CH}_2\text{Br} > \text{CH}_3\text{CH}_2\text{I}$
C  $>$  $>$ 
D $\text{CH}_2=\text{CHI}$ $>$  $>$ 

- 19 2-methylpropan-1-ol can be converted into 2-methylpropan-2-ol in two steps.



Which one of the following sequences may be used for the conversion?

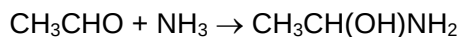
- | | Step 1 | Step 2 |
|----------|--------------------------------------|--|
| A | alcoholic KCN | dilute H_2SO_4 , heat under reflux |
| B | concentrated H_2SO_4 | cold alkaline KMnO_4 |
| C | Al_2O_3 with heating | H_2O with H_3PO_4 at high temperature and pressure |
| D | alcoholic NaOH | H_2O with H_3PO_4 at high temperature and pressure |

10

- 20 One of the earliest biotechnological processes, developed by Weizmann in 1911, was the conversion of starch into propanone and butan-1-ol.

Which reagent could be used to confirm the presence of propanone in a propanone / butan-1-ol mixture?

- A $\text{AgNO}_3(\text{aq})$ with an excess of $\text{NH}_3(\text{aq})$
 - B I_2 in $\text{NaOH}(\text{aq})$
 - C Acidified $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$
 - D Na
- 21 Ethanal can react with ammonia as shown.

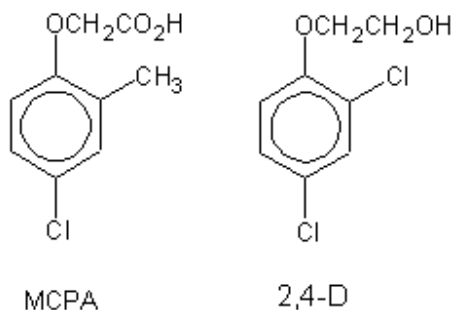


Which type of chemical reaction takes place?

- A addition – elimination
 - B electrophilic addition
 - C free-radical addition
 - D nucleophilic addition
- 22 Which reaction does **not** produce benzoic acid?
- A the hydrolysis of $\text{C}_6\text{H}_5\text{CO}_2\text{CH}_2\text{CH}_3$
 - B the hydrolysis of $\text{C}_6\text{H}_5\text{CN}$
 - C the oxidation of $\text{C}_6\text{H}_5\text{CH}_3$
 - D the oxidation of $\text{C}_6\text{H}_5\text{OH}$

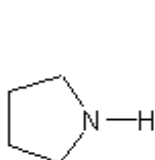
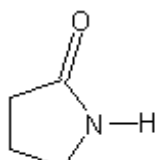
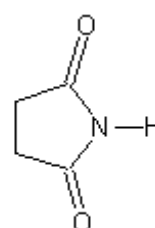
11

- 23 MCPA and 2,4-D are two widely-used selective weedkillers.



Which reagent will distinguish MCPA from 2,4-D?

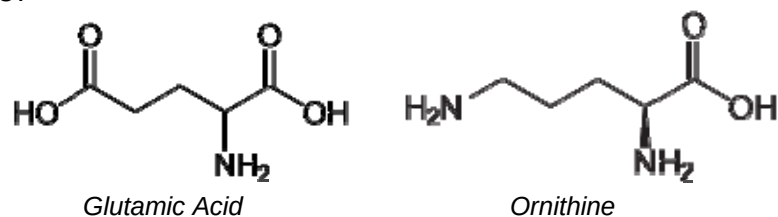
- A** PCl_5
- B** acidified $\text{AgNO}_3(\text{aq})$
- C** hot acidified $\text{KMnO}_4(\text{aq})$
- D** hot acidified $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$
- 24 Which of the following statements is **true** about the pH of an aqueous solution of the following compounds at 25 °C?

**X****Y****Z**

- | | | | |
|----------|--------|--------|--------|
| A | pH = 7 | pH = 7 | pH = 7 |
| B | pH > 7 | pH = 7 | pH < 7 |
| C | pH < 7 | pH = 7 | pH < 7 |
| D | pH > 7 | pH > 7 | pH > 7 |

12

- 25 Which one of the following statements is **false** about these two amino acid molecules?



- A The maximum number of possible compounds with 1 CONH bond formed from one glutamic acid molecule and one ornithine molecule is 5.
- B Both amino acids are likely to be found on the outer surface of a large globular protein molecule.
- C Both can be separated from each other by electrophoresis.
- D Isoelectric point of glutamic acid is higher than that of ornithine.
- 26 Silicon tetrachloride reacts with moist ethoxyethane to produce silicon oxochloride. When 0.10 g of the oxochlorides was reacted with water, all the chlorine atoms were converted into chloride ions, and produced 0.303 g of silver chloride was precipitated when an excess of aqueous silver nitrate was added.

What is the correct formula of the silicon oxochloride?

- A Si_2OCl_6
- B Si_3OCl_6
- C $\text{Si}_2\text{O}_2\text{Cl}_8$
- D $\text{Si}_3\text{O}_2\text{Cl}_8$

13

- 27 A student was given a sample of strontium carbonate that was mixed with strontium nitrate. He carried out two separate experiments using the same mass of the solid mixture.

Experiment 1: The sample was heated strongly to constant mass and the volume of gas evolved was found to be 200 cm^3 .

Experiment 2: Excess dilute sulfuric acid was added to the sample and volume of gas evolved was found to be 75 cm^3 .

All volumes were measured at the same temperature and pressure.

What is the mole ratio of strontium carbonate to strontium nitrate in the sample?

- A 3 : 2
B 3 : 5
C 6 : 5
D 9 : 5
- 28 When the salt CsI_yCl is heated, iodine vapour was evolved leaving behind caesium chloride. The iodine evolved requires 22.4 cm^3 of $0.100 \text{ mol dm}^{-3}$ of aqueous sodium thiosulfate for complete reaction. The solution of the residue in water requires 11.2 cm^3 of $0.100 \text{ mol dm}^{-3}$ aqueous silver nitrate for complete precipitation of silver chloride.

Determine the formula of the salt.

- A $\text{Cs}(\text{ICl})$
B $\text{Cs}(\text{I}_2\text{Cl})$
C $\text{Cs}(\text{ICl})_2$
D $\text{Cs}(\text{I}_2\text{Cl})_2$

- 
- Chemical structure of Carboplatin, a platinum-based anticancer drug. It features a central platinum (Pt) atom coordinated to two ammine (NH₃) groups and two cyclobutane-1,1-dicarboxylate ligands. The label "Carboplatin" is placed below the structure.

	Cisplatin	Carboplatin
A	+2	+2
B	+2	+4
C	+4	+2
D	+4	+4

- $$\underset{\text{pink}}{[\text{Co}(\text{H}_2\text{O})_6]^{2+}} + 4\text{Cl}^- \rightleftharpoons \underset{\text{blue}}{[\text{CoCl}_4]^{2-}} + 6\text{H}_2\text{O}$$

Which of the following statements about the reaction is **not** true?

- A** The forward reaction is endothermic.
- B** The stability constant of $[\text{CoCl}_4]^{2-}$ decreases when temperature is lowered.
- C** When the equilibrium mixture is heated, it will turn more blue.
- D** When $[\text{CoCl}_4]^{2-}$ changes into $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$, the oxidation number of the cobalt changes.

15

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

- 31** When two liquids are mixed, heat may be evolved if intermolecular bonds formed are stronger than those broken, even if there is no chemical reaction.

Which pairs of liquids, when mixed, will **not** give out heat?

- 1** CHCl_3 and C_6H_{14}
2 CCl_4 and CH_3OH
3 CHCl_3 and $(\text{CH}_3)_2\text{CO}$

- 32** The standard enthalpy changes of formation of four compounds are given below:

	C_2H_4	C_2H_6	C_4H_8	C_4H_{10}
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	+50	-85	-10	-125

Which of the following reactions are exothermic?

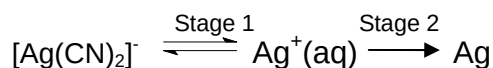
- 1** $\text{C}_4\text{H}_8 + \text{H}_2 \rightarrow \text{C}_4\text{H}_{10}$
2 $\text{C}_2\text{H}_4 + \text{C}_2\text{H}_6 \rightarrow \text{C}_4\text{H}_{10}$
3 $2\text{C}_2\text{H}_6 \rightarrow \text{C}_4\text{H}_{10} + \text{H}_2$

16

33 Which of the following statements are **correct** for all three halogens, chlorine, bromine and iodine?

- 1** Their enthalpy change of formation becomes less exothermic.
- 2** They all react with aqueous sodium hydroxide to form oxo-anions.
- 3** They all form hydrides that are strong acids in aqueous solution.

34 When copper is electroplated with silver, a solution containing both silver nitrate and potassium cyanide, KCN, is used. The process involves the sequence shown below.

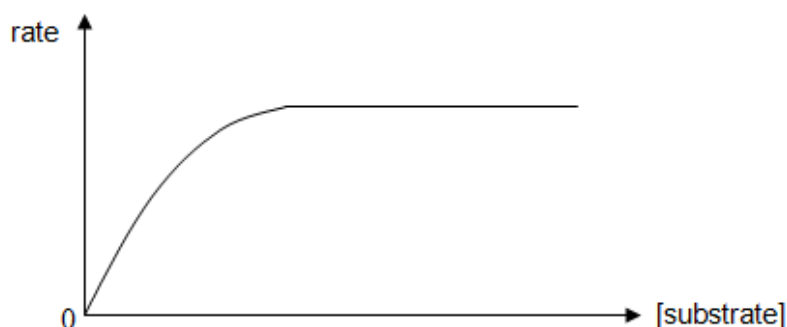


Which of the following statements are **true** of this sequence?

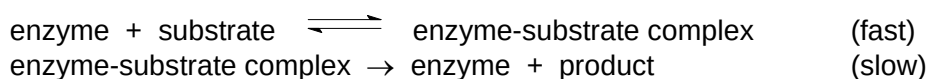
- 1** The cyanide ion reduces the concentration of the aqueous silver ions.
- 2** Both stages 1 and 2 involve a change in oxidation number.
- 3** The copper object will be the anode.

17

- 35 In an enzyme-catalysed reaction, the rate is affected by the concentration of substrate as shown in the graph below.



The steps that are common to most enzyme-catalysed reactions are

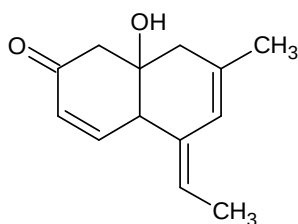


Which of the following conclusions can be drawn?

- 1 When [substrate] is low, the reaction is first order with respect to the substrate.
- 2 When [substrate] is high, the reaction is zero order with respect to the substrate.
- 3 The rate equation is given as: $\text{rate} = k [\text{enzyme-substrate complex}]$.

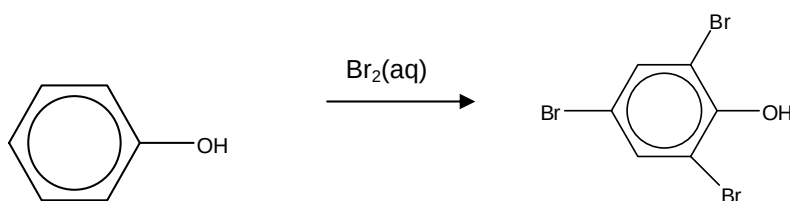
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- 36 Which of the following statements are **correct** with regards to the compound **K** shown below?

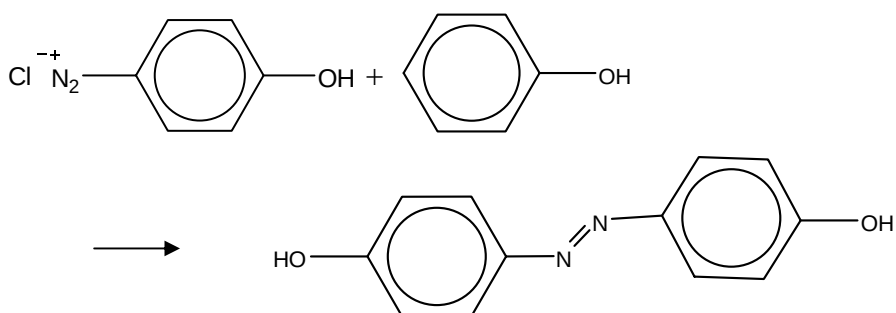
Compound **K**

- 1 1 mole of **K** reacts with excess gaseous HBr to yield a major product with 7 chiral centres.
 - 2 1 mole of **K** reacts with hot acidified KMnO_4 to give a tribasic carboxylic acid as one of the products.
 - 3 1 mole of **K** reacts with 4 moles of H_2 in the presence of nickel catalyst to yield a saturated compound.
- 37 Which reactions about phenol are examples of electrophilic substitution?

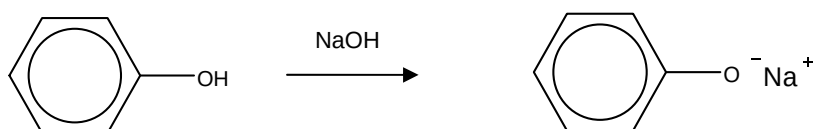
1



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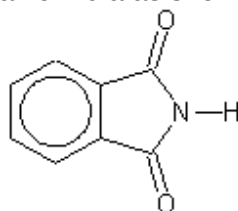


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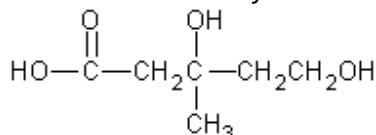
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- 38 Phthalimide has the structural formula as shown below:



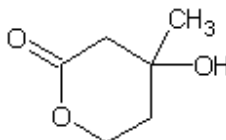
Which of the following statements about phthalimide are **true**?

- 1 It can react with boiling aqueous NaOH with the evolution of NH_3 .
 - 2 It can react with LiAlH_4 in dry ether to give a cyclic secondary amine.
 - 3 It can react with boiling dilute HCl to yield an amino acid.
- 39 Mevalonic acid is an intermediate in the biosynthesis of cholesterol.

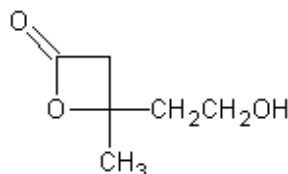


Which of the following statements are **true**?

- 1 It shows optical activity after oxidation with hot potassium manganate(VII).
- 2 It can undergo intramolecular esterification to produce this cyclic ester.

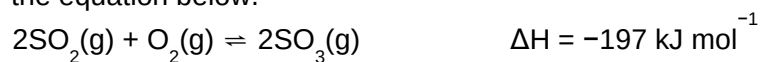


- 3 It is less likely to produce this cyclic ester due to high ring strain in ester.

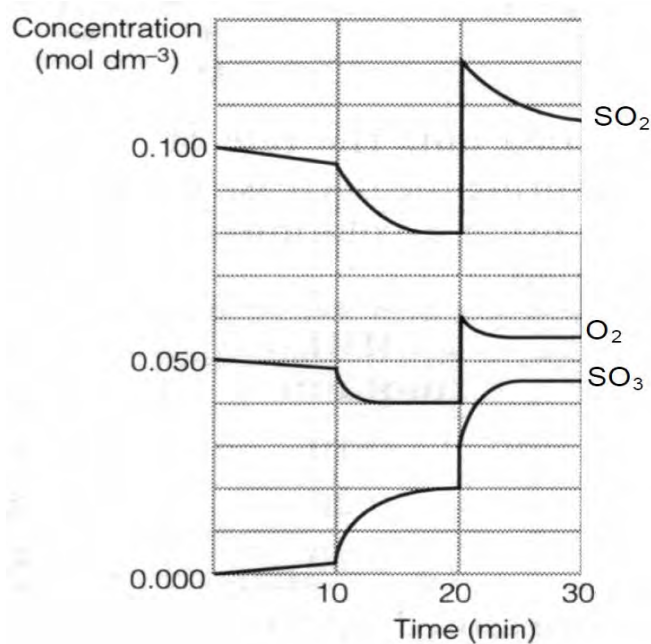


20

- 40 During the Contact process, sulfur dioxide is converted to sulfur trioxide as shown by the equation below.



The following graph shows how the concentration of the three gases changed when a series of changes was made.



Which conclusions can be drawn from this information?

- 1 At 20 minute, the numerical value of the equilibrium constant, K_c , is 1.56.
- 2 At 20 minute, the pressure of the system was increased by reducing the volume.
- 3 At 10 minute, some sulfur dioxide gas was removed from the system.

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