

RAFFLES INSTITUTION
2011 YEAR 6 PRELIMINARY EXAMINATION

HIGHER 2



CHEMISTRY

9647/01

Paper 1 Multiple Choice

26 September 2011

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Do not open this question booklet until you are told to do so.

Write in soft pencil.

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

Write your name, class and index number in the spaces provided on the Answer Sheet.

There are **forty** 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 to be correct and record your choice with a 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.

Section A

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

- 1 2.8 g of a metal, M, combines with 0.8 g of oxygen to form the oxide MO. The metal, M, also forms a second oxide in which the metal and oxygen are present in the ratio 7:3 by mass.

What is the formula of the second oxide?

- A** MO_2 **B** M_2O **C** M_2O_3 **D** M_3O_2

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

When x mol of vanadium is added to a solution containing y mol of vanadium(III) ions, vanadium(II) ions are formed in the resultant solution.

Which of the following are possible values of x and y if vanadium reacts completely and the resultant solution contains equal number of moles of vanadium(III) ions and vanadium(II) ions?

- | | x | y |
|----------|-----|-----|
| A | 1 | 2 |
| B | 1 | 3 |
| C | 1 | 5 |
| D | 2 | 3 |

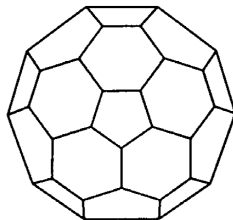
- 3 Bromine trifluoride is a liquid at room temperature. It shows an electrical conductivity high enough to indicate that some auto-ionisation occurs, which is usually represented by the following equation:



Which of the following is correct regarding BrF_3 , BrF_2^+ and BrF_4^- ?

- A** BrF_3 is planar while BrF_4^- is non-planar.
B BrF_2^+ is linear while BrF_4^- is tetrahedral in shape.
C The F–Br–F bond angle in BrF_3 is smaller than that in BrF_4^- .
D There are more lone pairs of electrons around the Br atom in BrF_3 than that in BrF_2^+ .
- 4 Which of the following **cannot** be explained by hydrogen bonding?
- A** the existence of the hydrogen-difluoride anion, HF_2^-
B the difference in volatility between pentan-1-ol and hexan-1-ol
C the difference in melting point between 2-nitrophenol and 4-nitrophenol
D the higher than expected relative molecular mass of ethanoic acid in benzene

- 5 Buckminsterfullerene has the formula, C_{60} . Its structure is shown below.



The bonding in buckminsterfullerene is similar to that in graphite.

Which of the following is correct?

- A All the bond angles in buckminsterfullerene are 120° .
 - B There are delocalised electrons in buckminsterfullerene.
 - C The melting point of buckminsterfullerene is higher than that of graphite.
 - D On complete combustion, buckminsterfullerene forms carbon dioxide and water.
- 6 Deuterium, 2H , is an isotope of hydrogen.

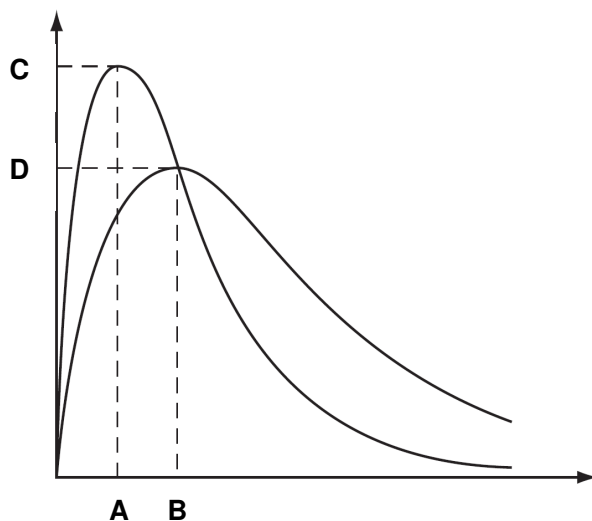
In an experiment, 3.7 g of a gas **X** at $25^\circ C$ was found to occupy the same volume as 0.368 g of deuterium gas at $17^\circ C$. Both gases were at the same pressure.

What is the relative molecular mass of the gas **X**?

- | | |
|--|--|
| A $\frac{2.0 \times 3.7 \times 25}{0.368 \times 17}$ | B $\frac{3.7 \times 298}{2.0 \times 0.368 \times 290}$ |
| C $\frac{4.0 \times 3.7 \times 290}{0.368 \times 298}$ | D $\frac{4.0 \times 3.7 \times 298}{0.368 \times 290}$ |

- 7 The diagram shows the Maxwell-Boltzmann energy distribution curves for molecules of a sample of a gas at two different temperatures.

Which letter on the axes represents the most probable energy of the molecules at the lower temperature?

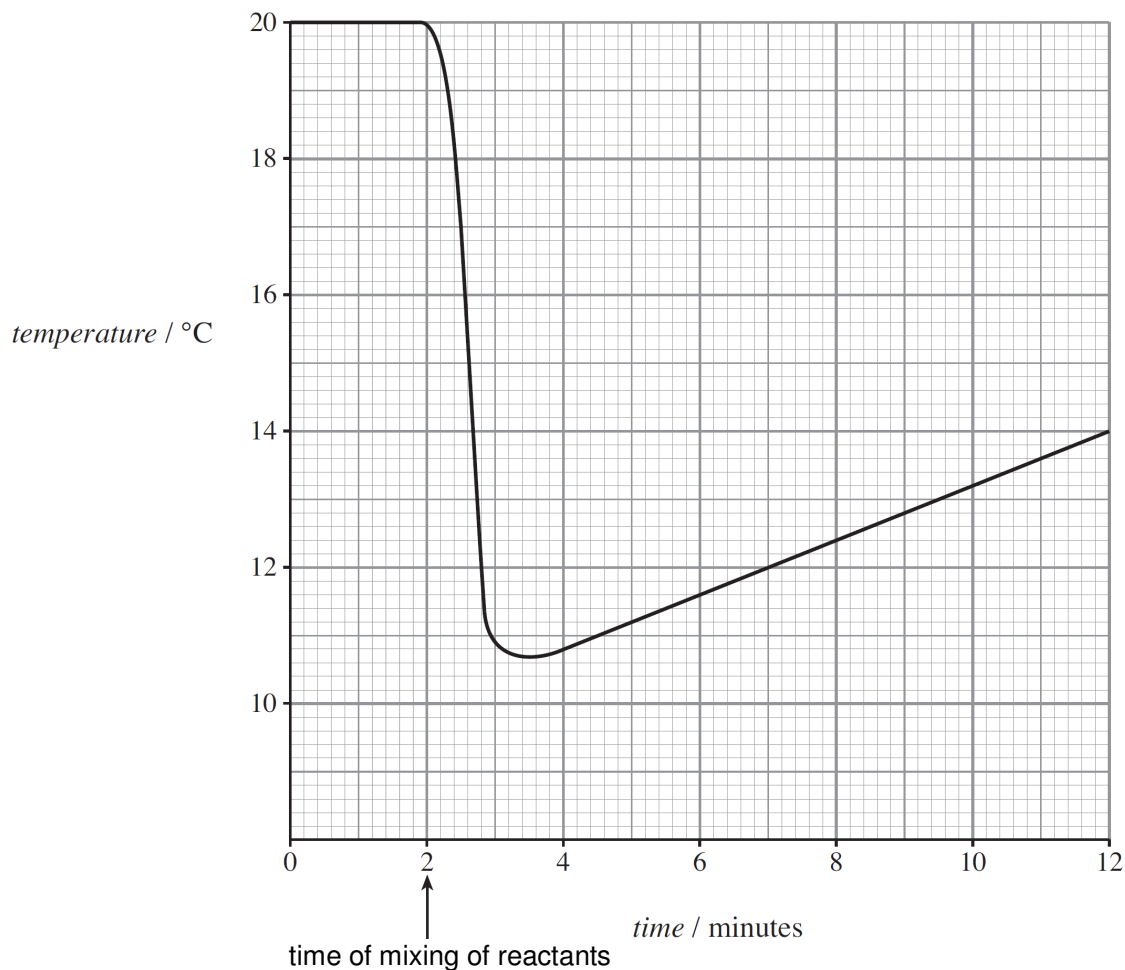


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8 Use of the Data Booklet is relevant to this question.

In an experiment to determine the enthalpy change of solution of ammonium nitrate in water, 8.00 g of solid ammonium nitrate ($M_r = 80.0$) was added to 50 g of water and the temperature of the resultant solution monitored at various time intervals.

Using data from the above experiment, the following graph was obtained.

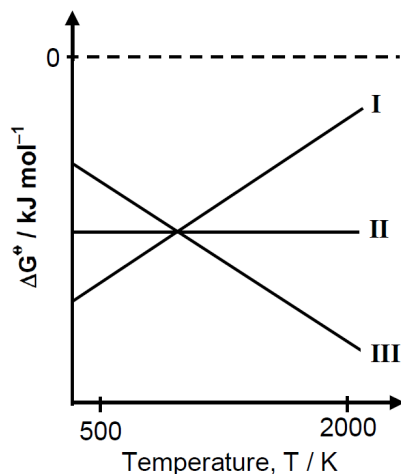


What is the enthalpy change of solution of ammonium nitrate based on the data from the above experiment?

- A** +19.4 kJ mol⁻¹
- B** +20.1 kJ mol⁻¹
- C** +20.9 kJ mol⁻¹
- D** +22.6 kJ mol⁻¹

- 9 In 1944, T. Ellingham published plots of ΔG° against temperature T for a number of reactions. Today, such plots are called Ellingham diagrams.

An Ellingham diagram for three reactions involving the oxidation of C and CO is shown below.



Which of the following shows correctly the three reactions corresponding to **I**, **II** and **III** in the above Ellingham diagram?

	I	II	III
A	$2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$	$\text{C} + \text{O}_2 \rightarrow \text{CO}_2$	$2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$
B	$2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$	$2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$	$\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
C	$\text{C} + \text{O}_2 \rightarrow \text{CO}_2$	$2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$	$2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$
D	$2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$	$2\text{C} + \text{O}_2 \rightarrow 2\text{CO}$	$\text{C} + \text{O}_2 \rightarrow \text{CO}_2$

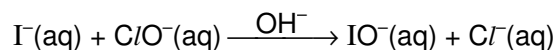
- 10 A chemical plant illegally dumped some radioactive waste in a landfill. This waste composed of two radioactive isotopes **M** and **N**. The half-life of **M** is 3 days whereas that of **N** is 2 days. The authorities found out about this illegal dumping only when the waste had been in the landfill for 12 days. They did an immediate analysis on a sample of the waste and found equal amounts of **M** and **N**.

Considering that the decay of radioactive isotopes follows first-order kinetics, what is the molar ratio of **M** to **N** if the waste had been in the landfill for 6 days?

	M	:	N
A	1	:	4
B	1	:	2
C	2	:	1
D	4	:	1

[Turn over

- 11** The kinetics of the reaction below was studied using the method of initial rates.

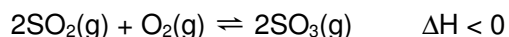


Experiment	Initial $[I^-]$ / mol dm ⁻³	Initial $[C/O^-]$ / mol dm ⁻³	Initial $[OH^-]$ / mol dm ⁻³	Initial rate / mol dm ⁻³ s ⁻¹
1	0.0013	0.012	0.100	9.4 x 10 ⁻³
2	0.0026	0.012	0.100	18.7 x 10 ⁻³
3	0.0013	0.018	0.100	14.0 x 10 ⁻³
4	0.0026	0.018	0.050	56.1 x 10 ⁻³

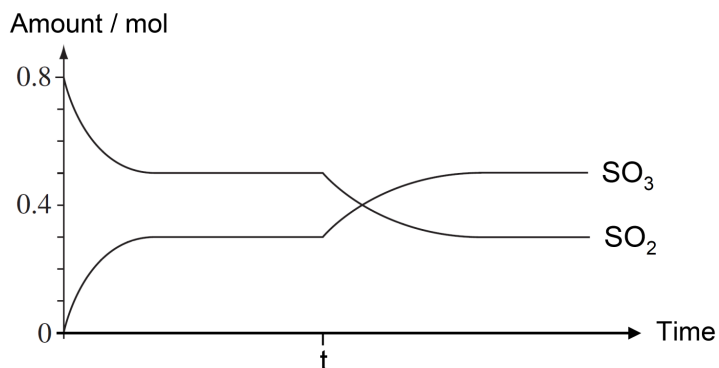
What is the overall order of the reaction?

- | | | | |
|----------|---|----------|---|
| A | 1 | B | 2 |
| C | 3 | D | 4 |

- 12** At a temperature T K, 0.80 mol of SO_2 and 0.40 mol of O_2 were introduced into a 10 dm^3 vessel and allowed to come to equilibrium.



The graph below shows the variations in the amounts of SO_2 and SO_3 in the system with time. A change was made to the system at time t .



What was the change made at time t ?

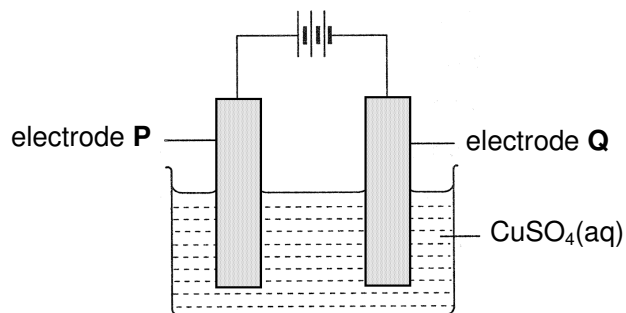
- A** a catalyst was added
B the temperature was decreased
C an inert gas was added at constant volume
D 0.05 mol of O_2 was added at constant volume

- 13** The pH of pure water is 6.88 at 32 °C. The pH of a saturated solution of a Group II hydroxide is 11.70 at the same temperature.

What is the numerical value of the solubility product of this hydroxide at 32 °C?

- A** 6.3×10^{-8} **B** 3.3×10^{-7}
C 1.3×10^{-5} **D** 3.8×10^{-5}

- 14 In an experiment, a cell was set up to obtain pure copper from a copper-silver alloy as shown below.



When a current of 40.0 A flows through the electrolyte for 26.8 minutes, the mass of the anode changes by 26.47 g.

Which of the following statements is correct?

- A Electrode **P** is pure copper and electrode **Q** is the copper-silver alloy.
 - B The concentration of $\text{CuSO}_4(\text{aq})$ decreases during the experiment.
 - C The mass of the cathode changes by 26.47 g during the experiment.
 - D The copper-silver alloy contains 20% silver by mass.
- 15 **X**, **Y** and **Z** are consecutive elements in Period 3 of the Periodic Table. Element **Z** has the lowest melting point and the highest second ionisation energy among the three elements.

What could be the atomic numbers of **X**, **Y** and **Z** respectively?

- A 11, 12 and 13
 - B 12, 13 and 14
 - C 13, 14 and 15
 - D 14, 15 and 16
- 16 Which of the following statements is correct for Group II elements and its compounds?
- A The reducing power of strontium is greater than that of barium.
 - B The solubility product of magnesium hydroxide is smaller than that of calcium hydroxide.
 - C The thermal decomposition temperature of calcium nitrate is higher than that of strontium nitrate.
 - D The covalent character in barium oxide is greater than that in magnesium oxide.

[Turn over

- 17 The element astatine, At₂, is radioactive with a short half-life. It is below iodine in the Periodic Table.

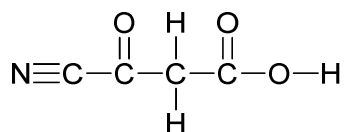
Which of the following statements is most likely to be correct for astatine or its compounds?

- A At₂ reacts with S₂O₃²⁻ to produce SO₄²⁻.
- B AgAt is soluble in concentrated aqueous NH₃.
- C KAt reacts with concentrated H₂SO₄ to produce H₂S and At₂.
- D HAt(aq) has a lower pH than HCl(aq) of the same concentration.

- 18 Which of the following reactions of first row transition metal ions is correct?

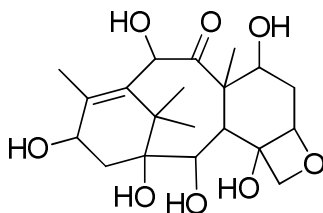
- A addition of Na₂CO₃(aq) to CrCl₃(aq) produces a green precipitate of Cr₂(CO₃)₃
- B addition of KI(aq) to Fe₂(SO₄)₃(aq) produces a brown precipitate of FeI₃
- C addition of NaOH(aq) to K₂CrO₄(aq) produces an orange solution of K₂Cr₂O₇
- D addition of concentrated HCl to CuSO₄(aq) produces a yellow solution of H₂[CuCl₄]

- 19 Which of the following reagents, upon reaction with compound **E**, gives only one sp² hybridised carbon atom in the product molecule?



compound **E**

- | | | | |
|---|---------------------------------|---|-------------------------------|
| A | SOCl ₂ | B | HCl(aq), heat |
| C | LiAlH ₄ in dry ether | D | NaBH ₄ in methanol |
- 20 *Taxol* is a drug isolated from the Pacific yew tree and is used in the treatment of lung and ovarian cancers. The tricyclic core of *Taxol* has the following structure.



In the reactions given below, the  ring remains unaltered.

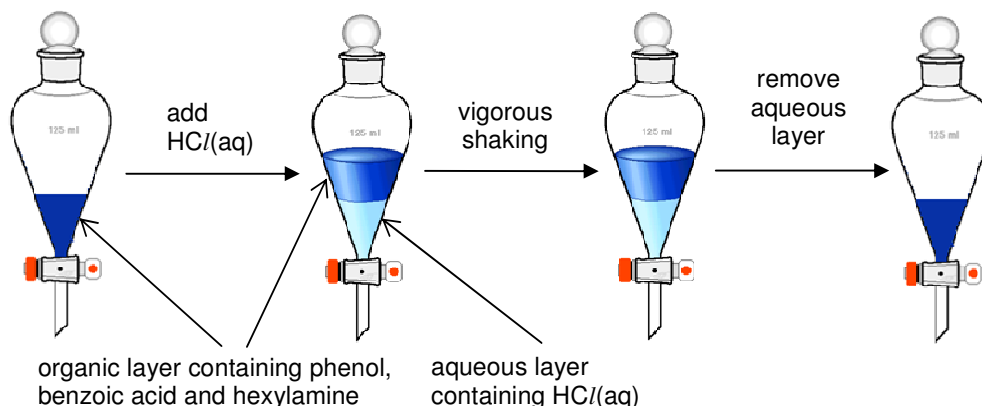
The tricyclic core was first reacted with H₂ and Pt catalyst, followed by hot acidified K₂Cr₂O₇.

How many chiral centres are present in the product of reaction?

- | | | | |
|---|---|---|----|
| A | 5 | B | 7 |
| C | 9 | D | 11 |

- 21 Extraction is a technique which makes use of a separatory funnel to separate organic compounds based on their different solubilities or different acid-base properties. Vigorous shaking allows compounds in the different layers to react.

An ether solution of phenol, benzoic acid and hexylamine was shaken with dilute HCl(aq) and the organic layer was separated from the aqueous layer.

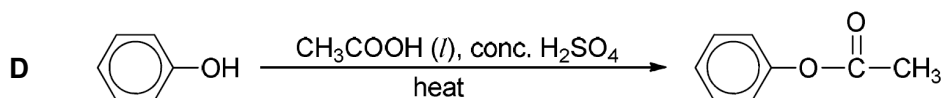
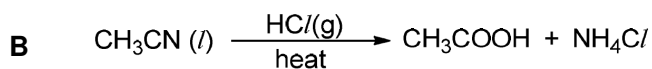
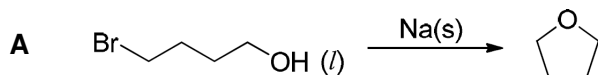


The series of steps was repeated with aqueous Na_2CO_3 and aqueous NaOH in separate experiments.

Which organic compound(s) will remain in the **organic layer** after treatment with the different aqueous solutions?

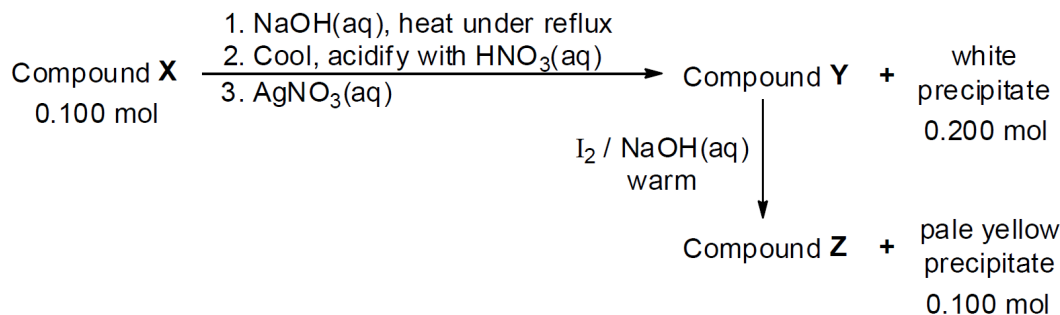
	treatment with HCl(aq)	treatment with $\text{Na}_2\text{CO}_3(\text{aq})$	treatment with NaOH(aq)
A	hexylamine	benzoic acid	benzoic acid and phenol
B	benzoic acid	phenol and benzoic acid	hexylamine
C	phenol and hexylamine	hexylamine	benzoic acid
D	benzoic acid and phenol	hexylamine and phenol	hexylamine

- 22 Which of the following transformations will occur under the given conditions?



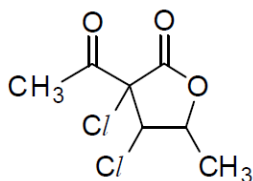
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23 Compound **X** was subjected to the following sequence of reactions.

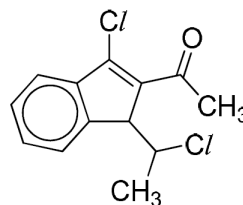


Which of the following could be the structure of **X**?

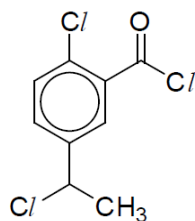
A



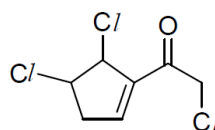
B



C

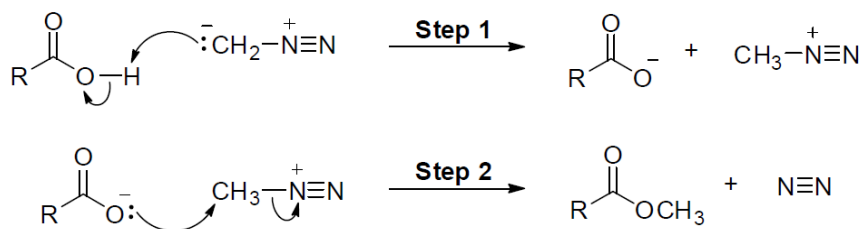


D



24 Diazomethane (CH_2N_2) is a highly explosive yellow gas which is known to explode upon gentle impact or exposure to light.

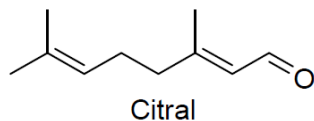
Despite the risks associated with its use, it is well known as an effective and efficient reagent in the preparation of methyl esters. Its mechanism is shown below.



What types of reaction took place in **Steps 1** and **2**?

	Step 1	Step 2
A	nucleophilic substitution	elimination
B	acid-base reaction	elimination
C	nucleophilic substitution	electrophilic addition
D	acid-base reaction	nucleophilic substitution

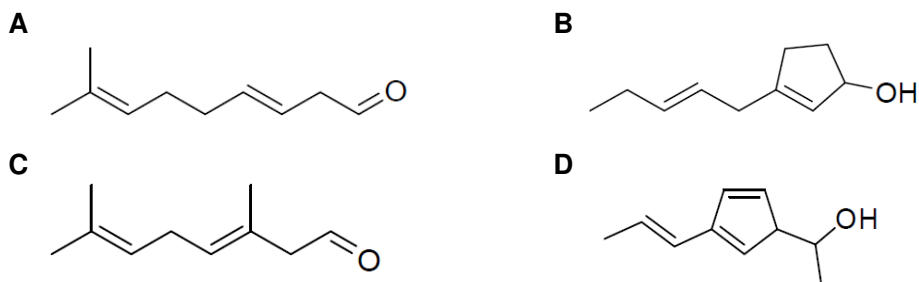
- 25 Compound **F** is an isomer of Citral.



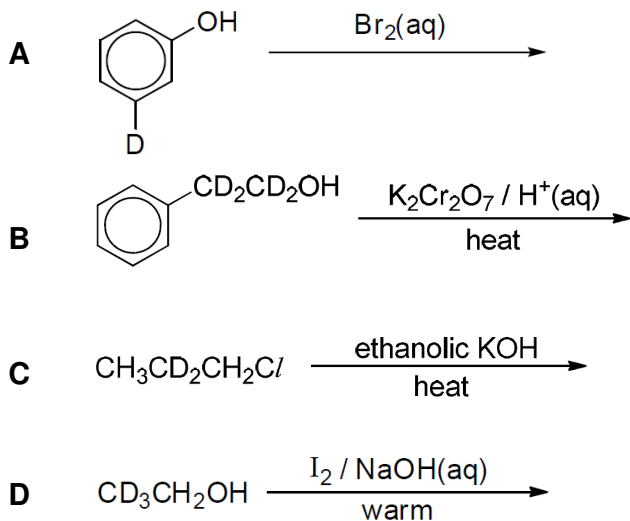
The reaction of **F** with hot acidified potassium manganate(VII) yields three products, **G**, **H** and **I**.

G can be converted to **H** with the use of aqueous alkaline iodine followed by acidification with aqueous sulfuric acid.

Which of the following shows the structure of compound **F**?



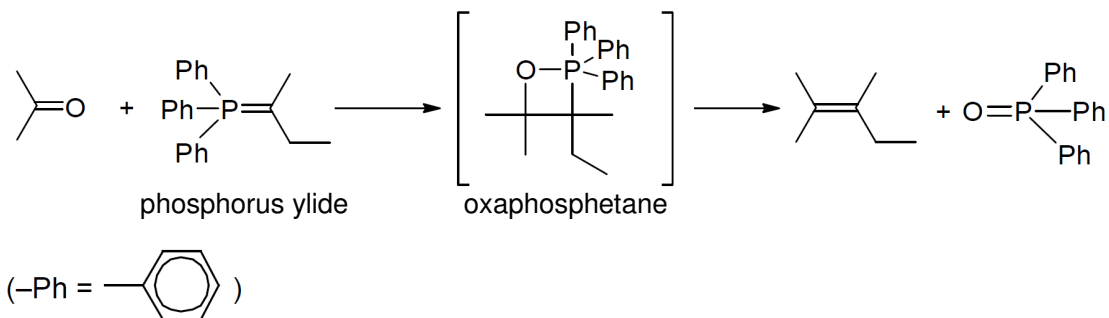
- 26 Which of the following reactions yields an organic compound which has **no** deuterium incorporated? (Deuterium, D = ^2H)



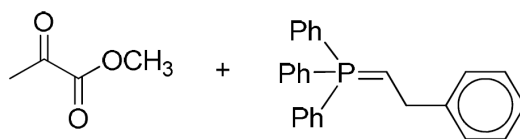
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The following information is relevant to questions **27** and **28**.

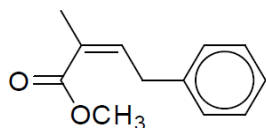
The Wittig reaction involves the reaction of a carbonyl compound with a phosphorus ylide to give an alkene. The reaction occurs because of an important oxaphosphetane intermediate.



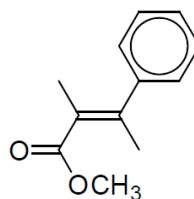
- 27** Which one of the following structures shows the product of the reaction between the following compound and the phosphorus ylide shown?



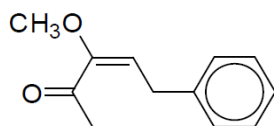
A



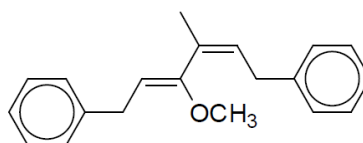
B



C



D

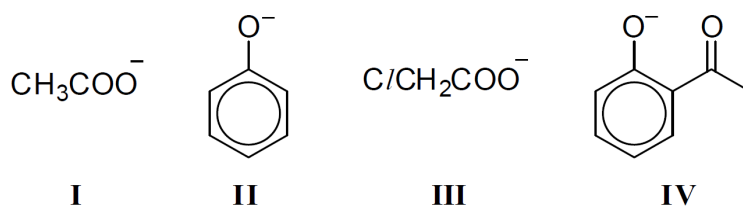


- 28** Reagents similar to the phosphorus ylide have been investigated to carry out the same reaction.

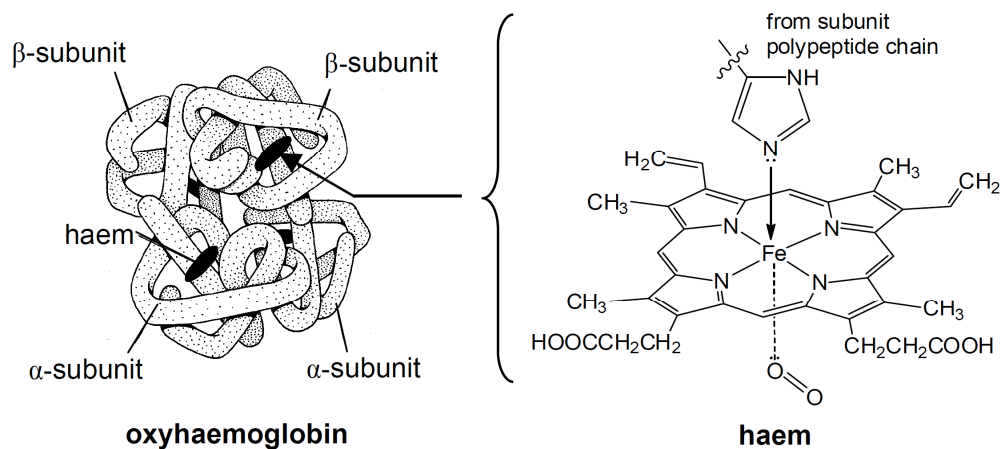
Which of the following atoms can be used in place of phosphorus to carry out the reaction?

- A** N
B O
C B
D Si

- 29 Which of the following sequences ranks the given species in order of decreasing K_b values?



- A** II, IV, I, III
B III, IV, I, II
C III, I, IV, II
D II, I, IV, III
- 30 The following diagram shows the structural components of oxyhaemoglobin, the oxygenated form of haemoglobin,



Which of the following statements about oxyhaemoglobin is correct?

- A** Each oxyhaemoglobin holds only one oxygen molecule.
B Oxyhaemoglobin comprises two α -helices and two β -sheets.
C A covalent bond helps to hold the haem group in each subunit.
D The subunits are held together by hydrogen bonds between the peptide linkages.

[Turn over

Section B

For each of the following questions, 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** For which of the following pairs does the first species contain fewer unpaired electrons than the second species?

- 1** C^+ , N^-
- 2** O^- , S^{2+}
- 3** Fe^{3+} , Cr

- 32** Which of the enthalpy changes of the following reactions can **only** be obtained by application of Hess' Law?

- 1** the combustion of glucose, $\text{C}_6\text{H}_{12}\text{O}_6$
- 2** the formation of methane from its elements
- 3** the hydration of anhydrous copper sulfate to form crystals of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$

- 33** Why does a mixture of hydrogen gas and bromine gas react together faster at a temperature of 450 K than it does at a temperature of 350 K?

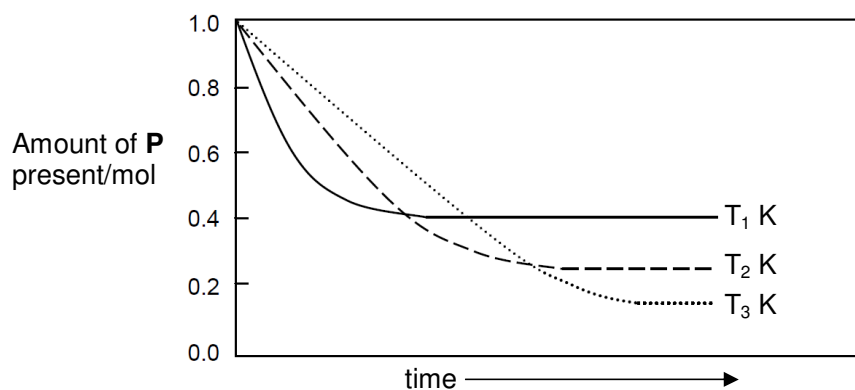
- 1** A higher proportion of effective collisions occurs at 450 K.
- 2** Hydrogen molecules and bromine molecules collide more frequently at 450 K.
- 3** The activation energy of the reaction is lower at 450 K.

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

- 34 A gas **P** decomposes to two other gases, **Q** and **R**, according to the equation:

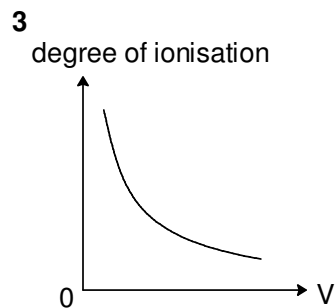
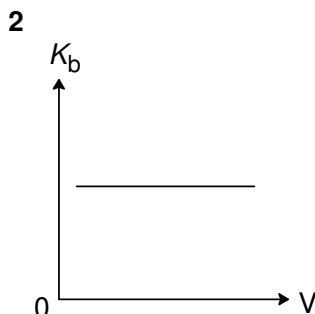
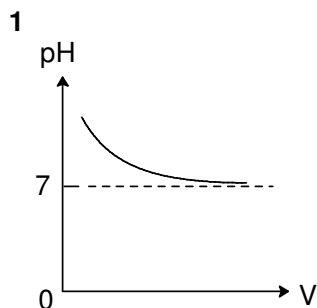


The graph below represents the decomposition of 1.0 mole of **P** in the presence of a catalyst at various temperatures.



Which of the following statements about the above system are correct?

- 1 The equilibrium constant, K_p , for the decomposition reaction increases with increasing temperature.
 - 2 At T_1 K, the mole fraction of **P** is greater than that of **R** at equilibrium.
 - 3 The decomposition reaction is spontaneous at all temperatures.
- 35 A sample of aqueous ammonia is diluted at constant temperature to a volume V . Which of the following diagrams are correct with regard to this solution?



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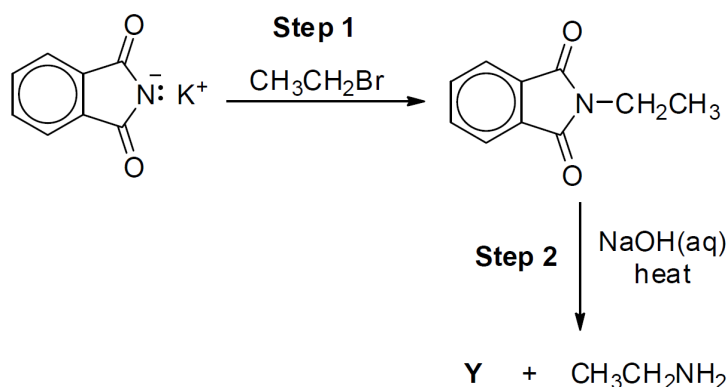
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

36 Use of the Data Booklet is relevant to this question.

Which of the following are chemically stable when left to stand in the atmosphere?

- 1 a solution of potassium hexacyanoferrate(III)
- 2 a solution of chromium(II) chloride
- 3 a mixture of aqueous sodium hydroxide and iron(II) sulfate

37 Potassium phthalimide is used in the preparation of primary amines from halogenoalkanes.

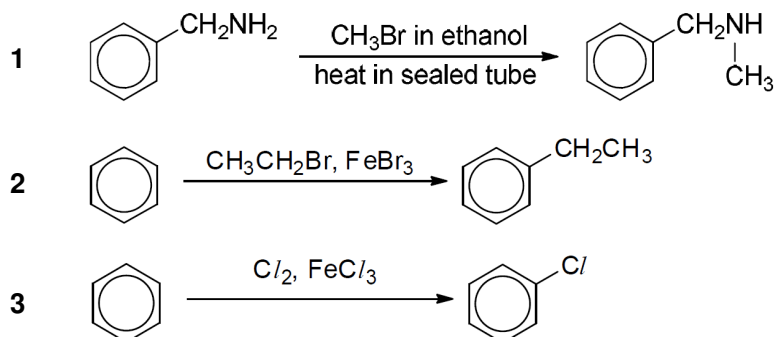


Which of the following statements about the above reaction are correct?

- 1 The use of $\text{CH}_3\text{CH}_2\text{I}$ instead of $\text{CH}_3\text{CH}_2\text{Br}$ in Step 1 increases the reaction rate.
- 2 Y is benzene-1,2-dicarboxylic acid.
- 3 Phenylamine can be prepared using this method.

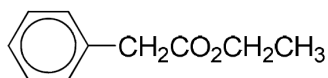
38 In a substitution reaction, when the product is more reactive than the original reactant, polysubstitution may occur.

In which of the following reactions will polysubstitution be likely to occur?



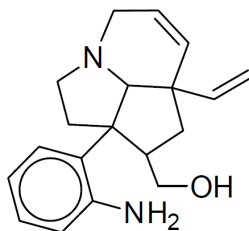
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

39 Which of the following synthetic routes will give the following ester as the product?



- 1 $\xrightarrow[\text{heat}]{\text{ethanolic KCN (aq)}}$ $\xrightarrow[\text{heat}]{\text{H}_2\text{SO}_4(\text{aq})}$ $\xrightarrow[\text{heat}]{\text{CH}_3\text{CH}_2\text{OH, conc. H}_2\text{SO}_4}$
- 2 $\xrightarrow[\text{heat}]{\text{KMnO}_4, \text{H}_2\text{SO}_4(\text{aq})}$ $\xrightarrow[\text{heat}]{\text{PCl}_5}$ $\xrightarrow{\text{CH}_3\text{CH}_2\text{OH}}$
- 3 $\xrightarrow[\text{heat}]{\text{KMnO}_4, \text{H}_2\text{SO}_4(\text{aq})}$ $\xrightarrow{\text{LiAlH}_4 \text{ in dry ether}}$ $\xrightarrow{\text{CH}_3\text{CH}_2\text{COCl}}$

40 Compound **X** is a synthetic precursor of *meloscine*, an alkaloid isolated from the New Caledonian plant *Melodinus Scandens* Forst.



compound **X**

Which of the following statements about its reactions are correct?

- 1 1 mol of **X** reacts with 5 mol of HBr(g) when heated.
- 2 1 mol of **X** reacts with 4 mol of Br₂(aq) at room temperature
- 3 1 mol of **X** reacts with 2 mol of CH₃COCl at room temperature.

————— End of Paper —————