HWA CHONG INSTITUTION
C2 Preliminary Examinations
Higher 2

CANDIDATE NAME		**CT GROUP**	**13S**
CENTRE NUMBER		**INDEX NUMBER**	

CHEMISTRY

9647/01

Paper 1 Multiple Choice

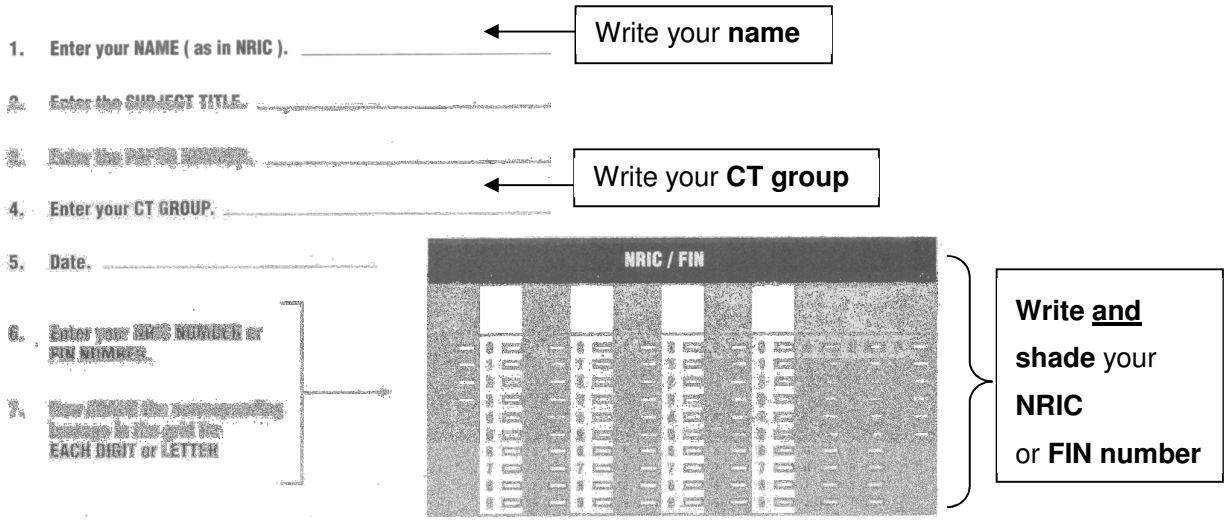
25 September 2014

1 hour

Additional Materials: Optical Mark Sheet (OMS)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Complete the information on the optical mark sheet (OMS) as shown below.



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 correct and record your choice in **soft pencil** on the OMS.

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

1 Consider the following half equations.

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$

To determine the concentration of Ca^{2+} ions in river water sample, 1.00 cm^3 of the water sample was first treated with excess aqueous $Na_2C_2O_4$. The CaC_2O_4 precipitate formed was filtered and treated with dilute aqueous H_2SO_4. The $C_2O_4^{2-}$ ions released into the solution required 10.00 cm^3 of 2.00×10^{-5} mol dm^{-3} acidified $KMnO_4$ for complete reaction.

What was the concentration of Ca^{2+} in the river water sample?

A 5.00×10^{-4} mol dm^{-3} **B** 8.00×10^{-5} mol dm^{-3}

C 5.00×10^{-7} mol dm^{-3} **D** 8.00×10^{-8} mol dm^{-3}

2 Chromium has four naturally occurring stable isotopes: ^{50}Cr, ^{52}Cr, ^{53}Cr, and ^{54}Cr.

Which statement about its ions is correct?

A $^{52}Cr^{3+}$ ion has less protons than $^{54}Cr^{3+}$ ion.

B The electronic configuration of $^{52}Cr^{3+}$ ion is $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^1$.

C The electronic configurations of $^{52}Cr^{3+}$ ion and $^{53}Cr^{3+}$ ion are different.

D $^{50}Cr^{3+}$ ion shows a greater angle of deflection than $^{52}Cr^{3+}$ ion in an electric field.

3 The successive ionisation energies of two elements, **P** and **Q**, are given below.

Ionisation energies / kJ mol^{-1}	1st	2nd	3rd	4th	5th	6th	7th	8th
P	740	1450	7720	10540	13630	18020	21700	25660
Q	1011	1907	2910	4960	6270	21270	25431	29872

What is the formula of the compound formed when **P** reacts with **Q**?

A $\mathbf{P_2Q_3}$ **B** $\mathbf{P_3Q_2}$

C $\mathbf{P_2Q_5}$ **D** $\mathbf{P_5Q_2}$

4 In an experiment, 2.0 g of a gas **Y** at 273 °C was found to occupy the same volume as 1.5 g of nitrogen gas at 298 °C. Both gases were at the same pressure.

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

A $\frac{2.0\times273\times28}{1.5\times298}$

B $\frac{1.5\times298\times28}{2.0\times273}$

C $\frac{2.0\times(273+273)\times28}{1.5\times(298+273)}$

D $\frac{1.5\times(298+273)\times28}{2.0\times(273+273)}$

5 The Ellingham diagram plots the free energy change of a reaction as a function of temperature, as given by the equation $\Delta G = \Delta H - T\Delta S$. A study was done involving the oxides of silicon.

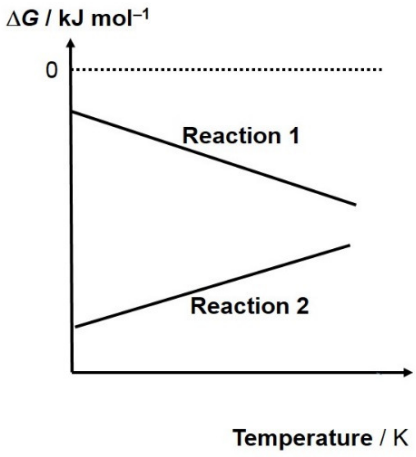
Silicon reacts with oxygen gas as shown:

Reaction 1: $2Si(s) + O_2(g) \rightarrow 2SiO(g)$

Reaction 2: $Si(s) + O_2(g) \rightarrow SiO_2(s)$

Which Ellingham diagram correctly corresponds to **reaction 1** and **reaction 2**?

A



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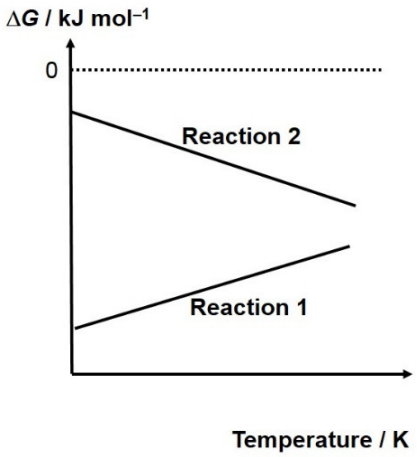

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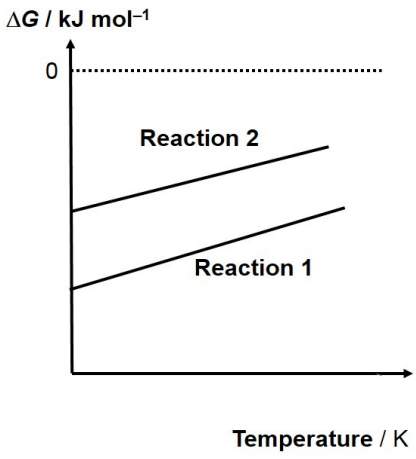

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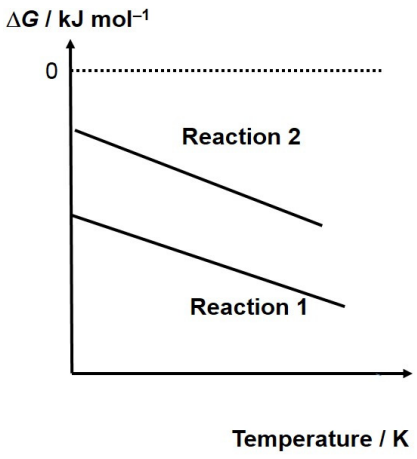


6 *Use of the Data Booklet is relevant to this question.*

A student connects a Zn^{2+}/Zn half-cell to a Fe^{3+}/Fe^{2+} half-cell. The voltage measured across the electrodes is found to be +1.50 V.

Which of the following could be a reason for the discrepancy between the calculated $E^{\ominus}_{cell}$ and the measured value?

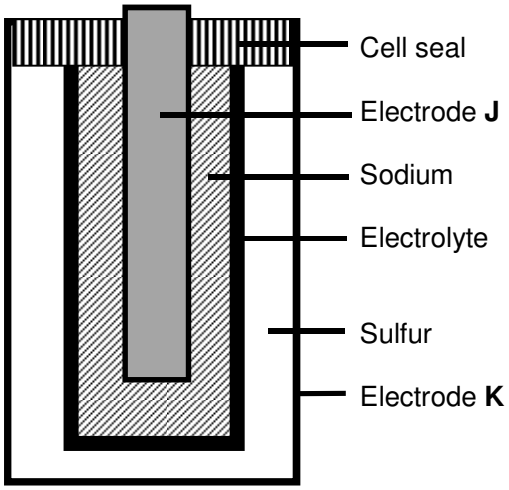
A Water is added to the Zn^{2+}/Zn half-cell.

B Water is added to the Fe^{3+}/Fe^{2+} half-cell.

C The piece of zinc in the Zn^{2+}/Zn half-cell used is too small.

D A small amount of NaCN(aq) is added to the Fe^{3+}/Fe^{2+} half-cell.

7 The diagram below shows the sodium-sulfur secondary cell, which is a type of molten-salt battery constructed from liquid sodium and sulfur.



During discharge, sulfur is reduced to polysulfide ion, S_x^{2-}.

Which statement about the cell is **incorrect**?

A The cell can be operated at room temperature.

B Electrode **J** is the negative terminal during discharging.

C The cell is potentially explosive if the seal is broken and water enters the cell.

D The polarities of electrodes **J** and **K** remain the same during charging and discharging.

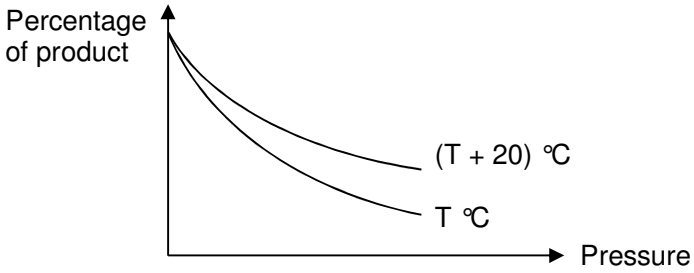
8 A pure sample of $NH_3(g)$ is introduced into an evacuated vessel of constant volume. This vessel is maintained at constant temperature such that the equilibrium below is established.

$$2NH_3(g) \ll N_2(g) + 3H_2(g)$$

The value of the final pressure is then found to be 40 % greater than if only NH_3 were present. What is the mole fraction of H_2 in the reaction mixture?

A 0.14 **B** 0.29 **C** 0.43 **D** 0.72

9 The graph below shows how the percentage of product present at equilibrium varies with temperature and pressure for a reaction.



Which reaction could the graph represent?

A $4Fe\ (s) + 3O_2\ (g) \ll 2Fe_2O_3\ (s)$ $\Delta H = -1644\ kJ\ mol^{-1}$

B $2C\ (s) + O_2\ (g) \ll 2CO\ (g)$ $\Delta H = -222\ kJ\ mol^{-1}$

C $N_2O_4(g) \ll 2NO_2(g)$ $\Delta H = +57\ kJ\ mol^{-1}$

D $CO(g) + Cl_2(g) \ll COCl_2(s)$ $\Delta H = +86\ kJ\ mol^{-1}$

10 Dimethyl sulfoxide, DMSO, is an organic solvent which can dissolve polar and non-polar compounds.

Ethanoic acid ionises in DMSO in the following manner:

$$CH_3CO_2H \ll CH_3CO_2^- + H^+$$

The pK_a of ethanoic acid in DMSO is 12.6.

What is the concentration of H^+ ions at equilibrium if 1.0×10^{-2} mol of ethanoic acid was dissolved in 500 cm^3 of DMSO?

A 5.0×10^{-8} mol dm^{-3} **B** 7.1×10^{-8} mol dm^{-3}

C 2.5×10^{-15} mol dm^{-3} **D** 5.0×10^{-15} mol dm^{-3}

11 Solid calcium hypochlorite pellets, $Ca(ClO)_2(s)$, are added to swimming pools to form $HClO(aq)$, which kills disease-causing bacteria and algae.

$$Ca(ClO)_2(s) \ll Ca^{2+}(aq) + 2ClO^-(aq)$$

$$ClO^-(aq) + H_2O(l) \ll HClO(aq) + OH^-(aq)$$

What is the effect on the solubility of calcium hypochlorite and bacterial growth when pH decreases?

	Solubility of calcium hypochlorite	Effect on bacterial growth
A	Decreases	More favourable
B	Decreases	Less favourable
C	Increases	More favourable
D	Increases	Less favourable

12 2.0 mol dm^{-3} of 2-bromo-2-methylpropane was reacted with an excess of hot aqueous sodium hydroxide. The following results were obtained.

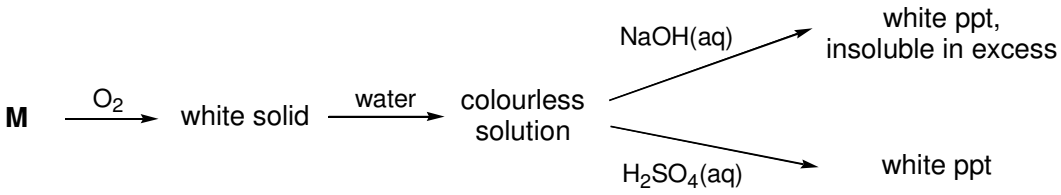
$$(CH_3)_3CBr + OH^- \rightarrow (CH_3)_3COH + Br^-$$

Time/min	0	15	40	80	∞
$[(CH_3)_3COH]$/ mol dm^{-3}	0	0.5	1.0	1.5	2.0

What is the value of the rate constant?

A 8.66×10^{-3} **B** 1.73×10^{-2} **C** 2.77×10^{-2} **D** 4.62×10^{-2}

13 Based on the information below, what could element **M** be?



A lead **B** calcium

C magnesium **D** zinc

14 HC*l* is stable to heat, but HI decomposes into its elements when heated.

What is the reason for this difference?

A HI is a stronger reducing agent than HC*l*.

B H–C*l* bond is more polar than H–I bond.

C H–C*l* bond is stronger than H–I bond.

D HI is more volatile than HC*l*.

15 Photographic film contains a mixture of silver chloride and silver bromide, which absorb light to undergo a 'self-redox' process to produce silver metal and halogens.

During the development of the film, a solution of aqueous sodium thiosulfate is used to dissolve the unreacted silver halides.

Which statement concerning the above processes is correct?

A AgBr can undergo 'self-redox' to a larger extent than AgC*l* as bromide is more readily oxidised.

B The silver halides produce halogens because the halides have high electron affinity.

C AgC*l* is more soluble than AgBr in aqueous sodium thiosulfate, as solubility product of AgC*l* is of a lower value.

D Silver metal forms a very stable complex, $[Ag(S_2O_3)_2]^{3-}$, with thiosulfate, hence silver halides are soluble.

16 The oxidation of tartrate ions, $C_4H_4O_6^{2-}$, by hydrogen peroxide is slow even at elevated temperatures. Addition of aqueous cobalt(II) chloride increases the rate of reaction.

$$C_4H_4O_6^{2-} + 3H_2O_2 \xrightarrow{Co^{2+}} 2CO_2 + 2HCO_2^- + 4H_2O$$

Which feature of cobalt makes it suitable as a catalyst for the above reaction?

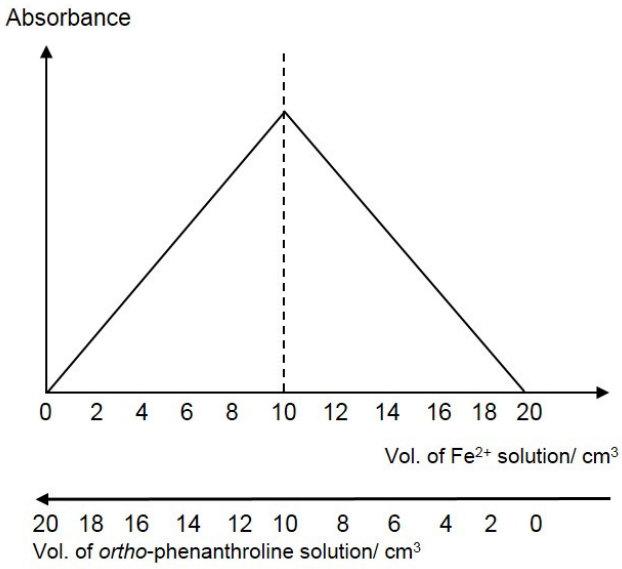
A It can form stable complexes.

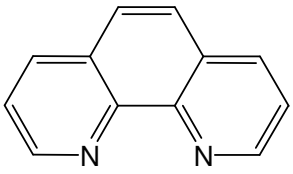
B It has variable oxidation states.

C It can undergo ligand exchange reactions.

D It has partially filled 3d orbitals for adsorption of reactant molecules.

17 Fe^{2+} ion forms a red complex with *ortho*-phenanthroline. Various samples containing different volumes of 1×10^{-5} mol dm^{-3} Fe^{2+} and 3×10^{-5} mol dm^{-3} *ortho*-phenanthroline were prepared. The following graph was obtained when the colour intensity of the samples was measured using a colorimeter.





ortho-phenanthroline

Which statement about the complex ion is correct?

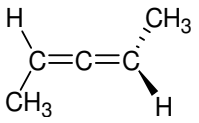
A The complex ion absorbs red light.

B The overall charge of the complex ion is –4.

C The co-ordination number of the Fe^{2+} ion is 2.

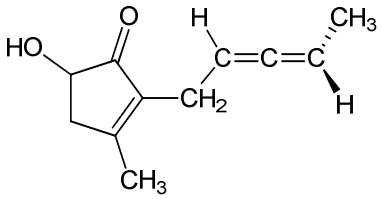
D The geometry of the complex ion is octahedral about Fe^{2+}.

18 1,3-dimethylallene is a chiral molecule that exists as a pair of enantiomers.



1,3-dimethylallene

Pyrethrolone is the first natural allene that was isolated in 1924.



pyrethrolone

Which statement about pyrethrolone is correct?

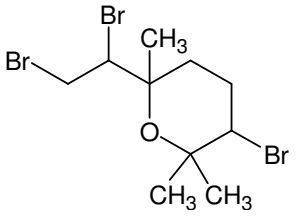
A It has 8 stereoisomers.

B The cyclopentene ring is planar.

C It contains 5 sp^2 hybridised carbon atoms.

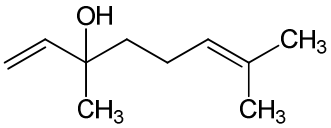
D It is not susceptible to attack by nucleophiles.

19 Linalool, $C_{10}H_{18}O$, is one of the constituents of lavender oil. When linalool is heated with concentrated potassium manganate(VII), C_3H_6O is one of the products. When linalool is reacted with excess liquid bromine, one of the products has the following structure.



What is the structure of linalool?

A



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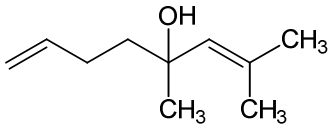

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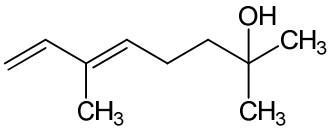
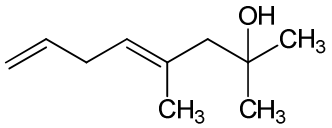


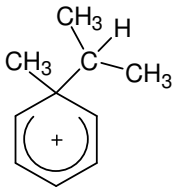
D



20 Methylbenzene can react with propene in the presence of hydrogen chloride.

Which of the following species shows the structure of the intermediate formed?

A



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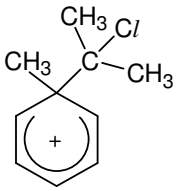

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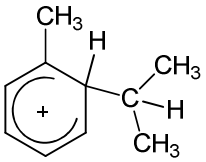

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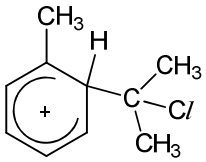
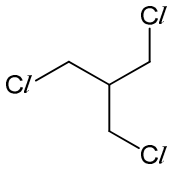


21 The presence of halogen in organic compounds may be detected by warming the organic compound with aqueous silver nitrate.

Which compound produces a precipitate most readily?

A



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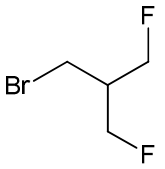

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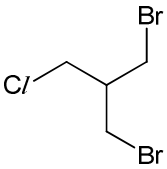

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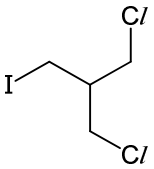
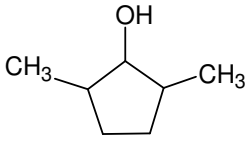


22 When the vapour of compound **X** is passed over hot aluminium oxide, 2 isomeric alkenes are formed but only one of them has a chiral centre. Compound **X** is also able to react with hot acidified potassium dichromate(VI).

Which compound could be **X**?

A



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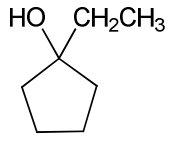
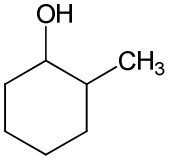


C



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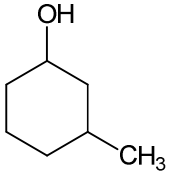
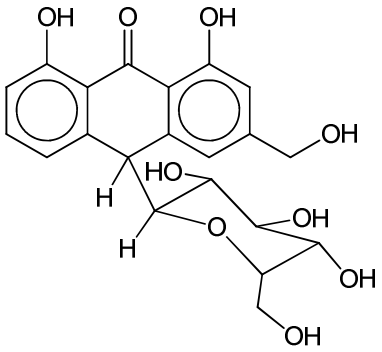


23 Barcaloin can be extracted from *Aloe* species and is used as a stimulant-laxative.



barcaloin

Four students made claims about the reactions of barcaloin.

W 1 mol of barcaloin reacts with 2 mol of Br_2(aq).

X 1 mol of barcaloin reacts with 5 mol of PCl_5(s).

Y 1 mol of barcaloin reacts with 5 mol of $CH_3CO_2H(l)$ under suitable conditions.

Z 1 mol of barcaloin reacts with 7 mol of NaOH(aq).

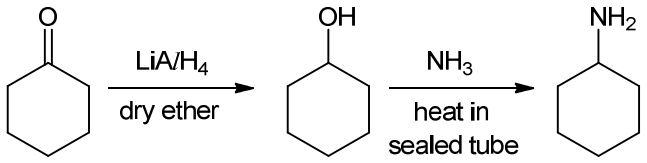
The ether group C–O–C does not undergo any reaction.

Which students' claims are correct?

A **W** and **X** **B** **X** and **Y** **C** **Y** and **Z** **D** **W** and **Z**

24 Which reaction scheme can produce the final product?

A



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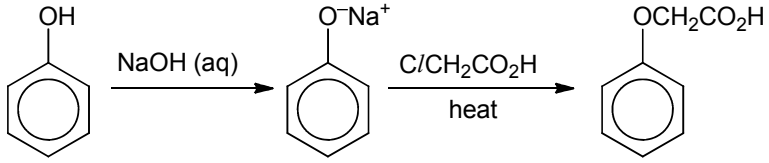

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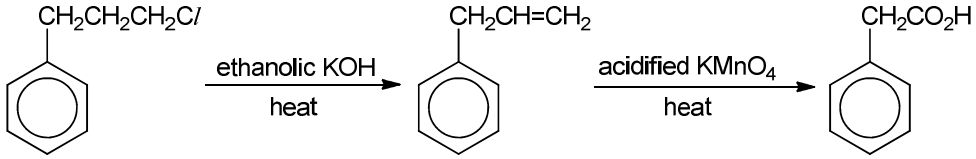

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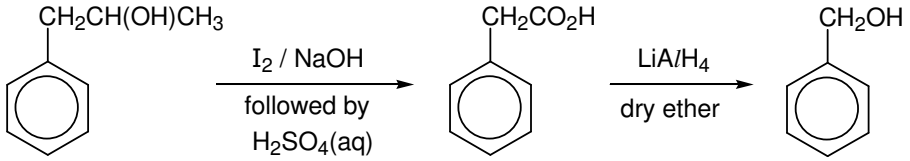
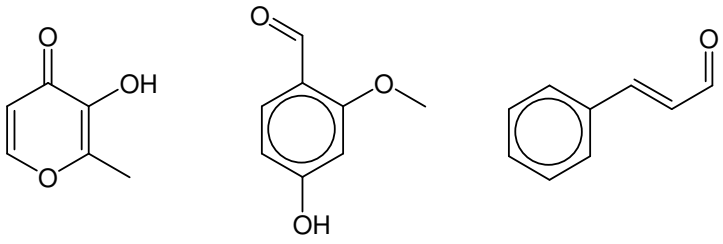


25 Maltol, vanillin and cinnamaldehyde are some naturally occurring flavouring agents.



maltol vanillin cinnamaldehyde

Which pair of reagents, when added separately to the three compounds, would enable them to be distinguished from one another?

	Reagent 1	Reagent 2
A	2,4-dinitrophenylhydrazine	Hot acidified $K_2Cr_2O_7$
B	Tollen's reagent	Neutral $FeCl_3$
C	Fehling's solution	Hot acidified $KMnO_4$
D	Alkaline aqueous iodine	Aqueous Br_2

26 Which compound will **not** give tri-iodomethane on warming with alkaline aqueous iodine?

A $CI_3CH(OH)CH_2Cl$

B $ICH_2COCH_2CH_3$

C $C_6H_5CH_2COCH_3$

D CH_3OCOCH_3

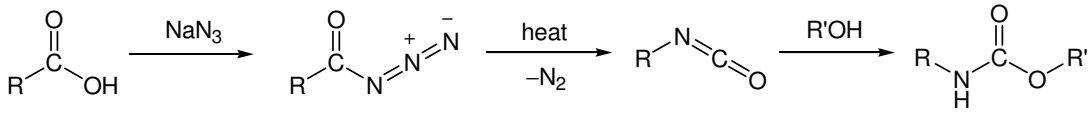
27 Equal amounts of compounds **P**, **Q** and **R** are separately shaken with 50 cm^3 of water. The pH of each resultant solution is then measured.

$ClCH_2CH_2CO_2H$	$CH_3CHClCO_2H$	$HOCH_2CH_2COCl$
P	**Q**	**R**

How will the pH of the solutions compare?

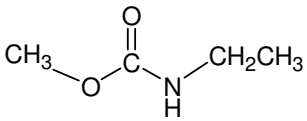
	lowest pH ⟶ highest pH		
A	**P**	**Q**	**R**
B	**Q**	**P**	**R**
C	**R**	**P**	**Q**
D	**R**	**Q**	**P**

28 The carbamate functional group can be synthesised from a carboxylic acid, RCO_2H, and an alcohol, R'OH, as shown below.



carbamate

Which pair of carboxylic acid and alcohol could give compound **X**?

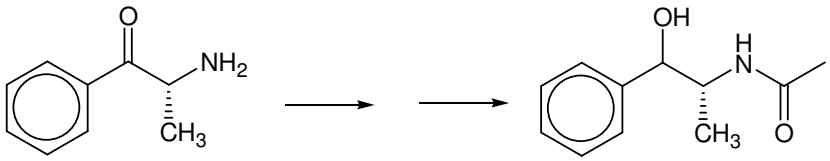


compound **X**

	carboxylic acid	alcohol
A	$CH_3CH_2CO_2H$	CH_3OH
B	$CH_3CH_2CO_2H$	CH_3CH_2OH
C	CH_3CO_2H	CH_3OH

D	CH_3CO_2H	CH_3CH_2OH

29 Compound **Y** is a derivative of cathinone, a naturally occurring stimulant found in the khat plant.



cathinone **Y**

Which series of transformations would allow for the conversion of cathinone to **Y**?

	Step 1	Step 2
A	$NaBH_4$	CH_3CO_2H
B	$NaBH_4$	CH_3COCl
C	CH_3CO_2H	$NaBH_4$
D	CH_3COCl	$NaBH_4$

30 The enzyme, trypsin, hydrolyses a peptide bond at the carboxylic end of the amino acid residues, lysine (lys) and arginine (arg). Another enzyme, chymotrypsin, hydrolyses a peptide bond at the carboxylic end of the phenylalanine (phe) residue.

When hexapeptide **Z** was separately hydrolysed by trypsin and chymotrypsin, the following fragments were obtained.

After trypsin hydrolysis	*After chymotrypsin hydrolysis*
phe	ala-lys-phe
ala-lys	gly-arg-phe
phe-gly-arg	

What is the primary structure of hexapeptide **Z**?

A phe-ala-lys-phe-gly-arg

B phe-gly-arg-ala-lys-phe

C ala-lys-phe-gly-arg-phe

D gly-arg-phe-ala-lys-phe

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.

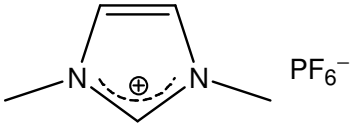
31 Which of the following statements are correct?

1 The number of atoms in a 2.0 g sample of $^{1}H_2$ is twice of that in a 12.0 g sample of ^{12}C.

2 1 mol of potassium sulfate, K_2SO_4 dissolves in water to form 1.8×10^{24} ions.

3 48 g of ozone, $^{16}O_3$ contains 1.8×10^{24} molecules.

32 Ionic liquids (salts in liquid state) have garnered much attention amongst chemists due to their wide applications in chemical industries. The structure of an imidazolium-based ionic liquid is shown below.



Which statements about this ionic liquid are correct?

1 It has low volatility.

2 It could be used as an electrolyte.

3 It is miscible with ethanol.

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.

33 Electroplating is an electrolytic process of coating an object with a thin layer of metal.

Which of the following factors will affect the mass of chromium deposited at the cathode during the process of electroplating?

1 Magnitude of current

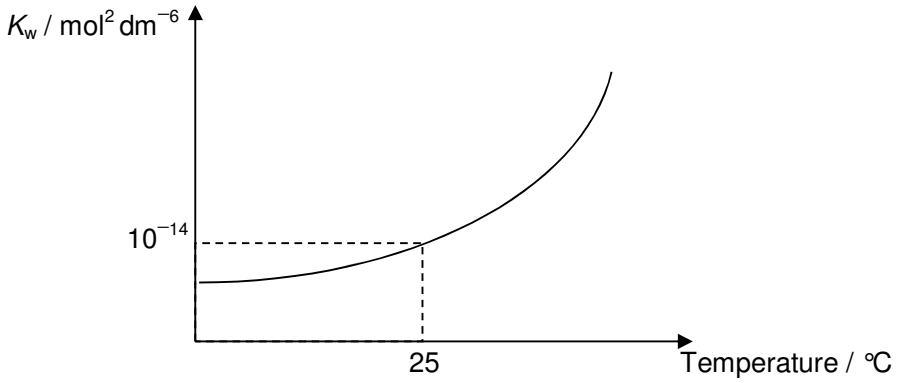
2 Concentration of electrolyte

3 Size of the cathode

34 Water dissociates as shown:

$$H_2O(l) \ll H^+(aq) + OH^-(aq)$$

The ionic product of water, K_w, varies with temperature as shown in the graph below.



Assuming that $[H_2O]$ = 55.6 mol dm^{-3}, which statements about the above equilibrium system are correct?

1 The pH of water decreases as temperature increases.

2 The concentrations of H^+ and OH^- are equal at all temperatures.

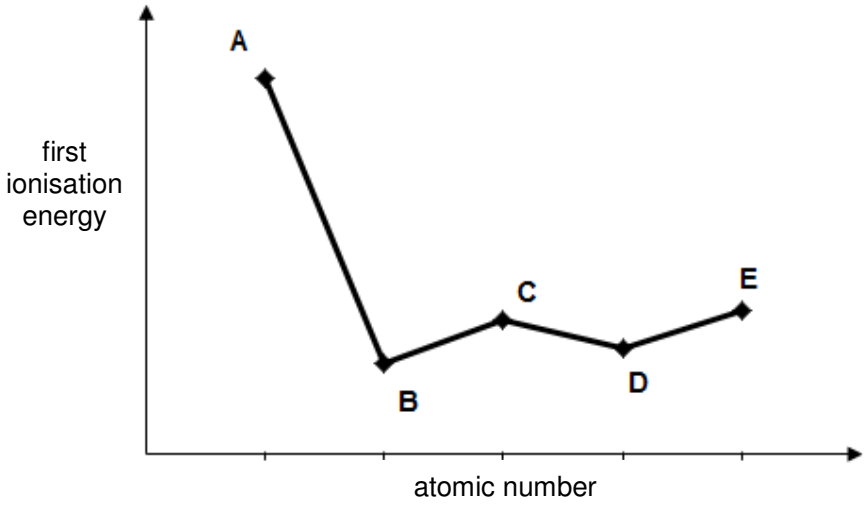
3 At 25 °C, K_a is numerically larger than K_w.

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.

35 The graph below shows the first ionisation energy of five consecutive elements **A** to **E** which are found in Period 2 or 3 in the Periodic Table.



Which statements about their compounds are correct?

1 When 2 mol of dilute HC*l* is added to 1 mol of the oxide of **C**, the resulting solution is neutral.

2 The oxide of **D** is insoluble in water but dissolves when the oxide of **B** is added to the mixture.

3 The covalent character of the chlorides increases from **B** to **D**.

36 Which statements concerning calcium, strontium and barium are correct?

1 The thermal stability of their hydroxides decreases down the group.

2 Their oxides react with cold water to give alkaline solutions.

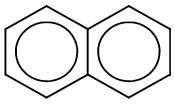
3 Their reactivity increases down the group.

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.

37 Napthalene, like benzene, is an aromatic compound that has a wide range of industrial applications.



naphthalene

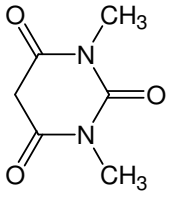
Which statements about naphthalene are correct?

1 It undergoes substitution rather than addition reactions.

2 All carbon-carbon bond lengths are intermediate between those of a C–C bond and a C=C bond.

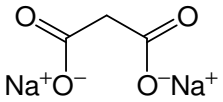
3 It reacts with bromine in the presence of a suitable catalyst to form two monobromo compounds.

38 1,3-dimethylbarbituric acid is commonly used as a starting material for the preparation of derivatives with pharmacological properties.



1,3-dimethylbarbituric acid

What are the products of its complete hydrolysis by aqueous sodium hydroxide?

1 

2 CH_3NH_2

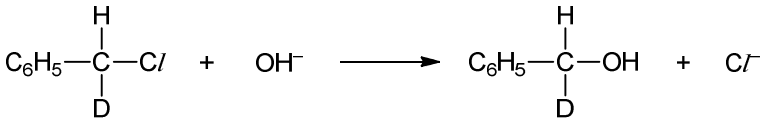
3 Na_2CO_3

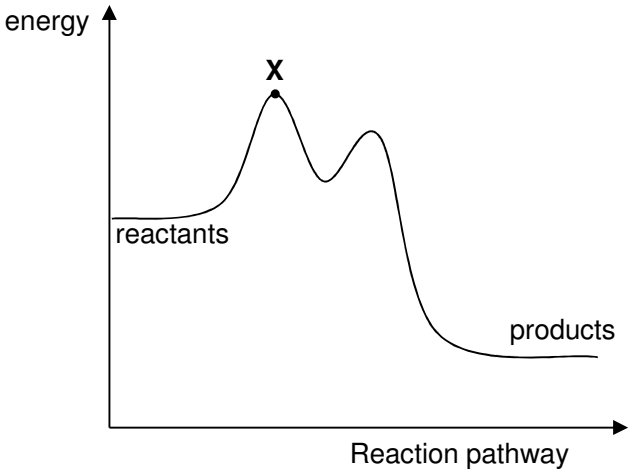
The responses **A** to **D** should be selected on the basis of

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.

39 The energy profile for the following reaction is shown below. [D = ^{2}H]



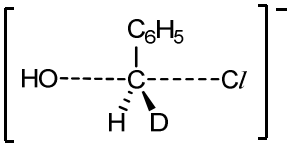


Which conclusions can be drawn?

1 The product has no effect on the rotation of plane polarised light.

2 The rate of reaction can be increased by increasing concentration of OH^-.

3 The structure of the transition state at point **X** is



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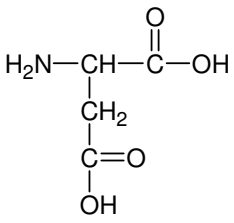
The responses **A** to **D** should be selected on the basis of

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

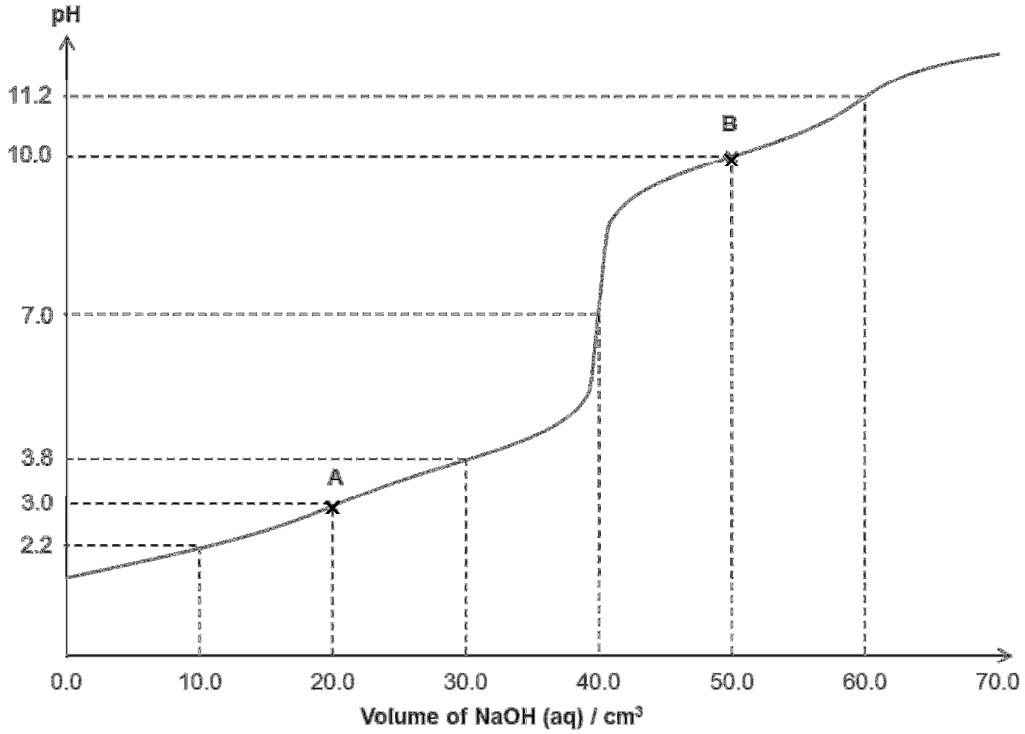
No other combination of statements is used as a correct response.

40 Aspartic acid is an amino acid with an acidic side-chain.



aspartic acid

20.0 cm^3 of a 0.10 mol dm^{-3} solution of aspartic acid was titrated against 0.10 mol dm^{-3} sodium hydroxide. The following pH curve was obtained.



What deductions can be made from the curve?

1 The three pK_a values of aspartic acid are 2.2, 3.8 and 10.0.

2 The major species present at point **A** is electrically neutral.

3 Equal amounts of $H_2NCH(CO_2^-)CH_2CO_2^-$ and $H_3N^+CH(CO_2^-)CH_2CO_2^-$ are present at point **B**.