| Name: | | Index Number: | | Class: | |
|---|---|---|---|---|---|

# DUNMAN HIGH SCHOOL
# Preliminary Examination
# Year 6

## H2 CHEMISTRY

9647/01

Paper 1 Multiple Choice

**30 September 2014**

**60 minutes**

Additional Materials: Optical Mark Sheet
Data Booklet

**INSTRUCTIONS TO CANDIDATES**

1 Write your **name**, **index number** and **class** on this question paper.

2 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 separate Optical Mark Sheet.

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

4 Any rough working should be done in this booklet.

5 You may use a calculator.





**[Turn over**

## 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.*

A car releases 0.46 g of an oxide of nitrogen $N_xO_y$ in the atmosphere. The gas released occupies a volume of 120 $cm^3$ at room temperature and pressure.

What are the values of *x* and *y*?

**A** $x = 1, y = 1$ **B** $x = 1, y = 2$

**C** $x = 2, y = 1$ **D** $x = 2, y = 4$

**2** In an aqueous solution, 1 mol of $MnO_4^-$ ions oxidises 3 mol of $Fe^{2+}$ ions.

What is the manganese–containing product in this reaction?

**A** $Mn^{2+}$ **B** $MnO_4^{2-}$

**C** $Mn^{3+}$ **D** $MnO_2$

**3** The successive ionisation energies (IE) of two elements **X** and **Y**, are given below:

| IE / kJ $mol^{-1}$ | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
|---|---|---|---|---|---|---|---|
| **X** | 786 | 1580 | 3230 | 4360 | 16000 | 20000 | 23600 |
| **Y** | 1310 | 3390 | 5320 | 7450 | 9500 | 11660 | 33604 |

The compound formed when **X** and **Y** combine is most likely to be

**A** $XY_3$ **B** $XY_2$ **C** $X_2Y$ **D** $XY_4$

**4** Which of the following deviates **most** from ideal gas behaviour at room temperature and pressure?

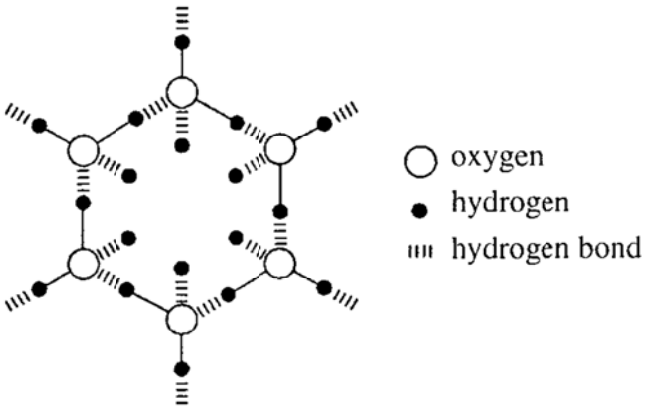
**A** oxygen

**B** helium

**C** nitrogen dioxide

**D** fluorine

**5** The diagram shows part of the structure of ice.




Which statement is **correct**?

**A** All bond angles surrounding each oxygen atom are 120°.

**B** Four electrons from each oxygen atom are involved in forming hydrogen bonds.

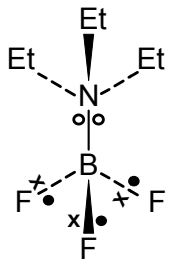
**C** The hydrogen bonds, shown by the dash lines, are stronger than the O–H covalent bonds.

**D** The open structure of ice causes ice to be denser than water.

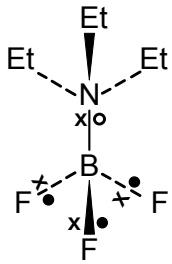
**6** Triethylamine, $Et_3N$, reacts with boron trifluoride, $BF_3$, to form a compound of formula $Et_3N.BF_3$.
[the symbol Et = $CH_2CH_3$]

In the following diagrams, **x**, • and ○ represent electrons from B, F and N respectively. Which diagram correctly illustrates **both** the shape of $Et_3N.BF_3$, and electron pairs around the boron atom?

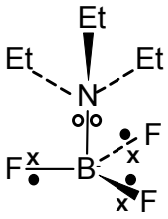
**A**



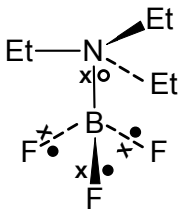
**B**



**C**



**D**



**7** On the sole basis of bond energies given in the table below, predict the **major** organic product of the following reaction.

$$CH_3CH(CH_3)CH_2CH(CH_3)CH_3 + Cl_2 \rightarrow C_7H_{15}Cl + HCl$$

| bond | bond energy / kJ mol$^{-1}$ |
|---|---|
| H–$CH_2$R | +420 |
| H–$CHR_2$ | +401 |
| H–$CR_3$ | +390 |
| C*l*–$CH_2$R | +338 |
| C*l*–$CHR_2$ | +339 |
| C*l*–$CR_3$ | +330 |

(R = alkyl group)

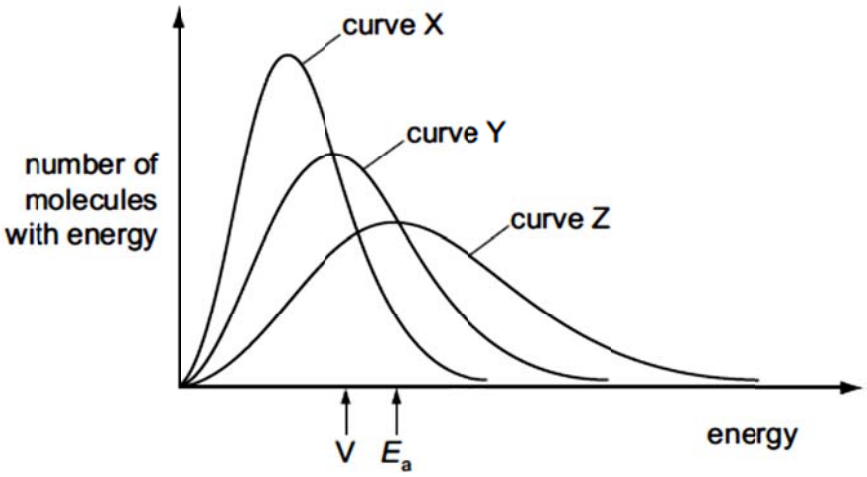
**A** $CH_3CH(CH_2Cl)CH_2CH(CH_3)CH_3$

**B** $CH_3CH(CH_3)CHClCH(CH_3)CH_3$

**C** $CH_3CCl(CH_3)CH_2CH(CH_3)CH_3$

**D** $CH_3CH(CH_3)CH_2CH(CH_3)CH_2Cl$

**8** Curve **Y** and the value $E_a$ represent the energy distribution of molecules and the activation energy for a gaseous reaction at 298 K respectively.




Which is a possible outcome if the reaction takes place at 288 K?

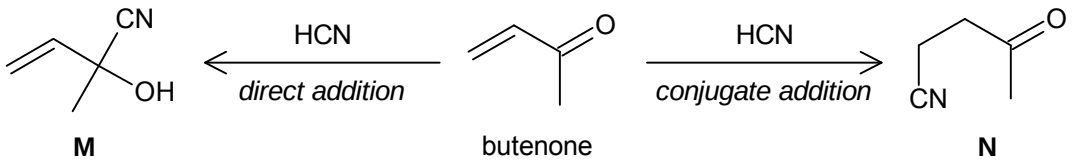
**A** The distribution of energies will be given by curve **Z** and the activation energy by value **V**.

**B** The distribution of energies will be given by curve **Z** and the activation energy by value $E_a$.

**C** The distribution of energies will be given by curve **X** and the activation energy by value **V**.

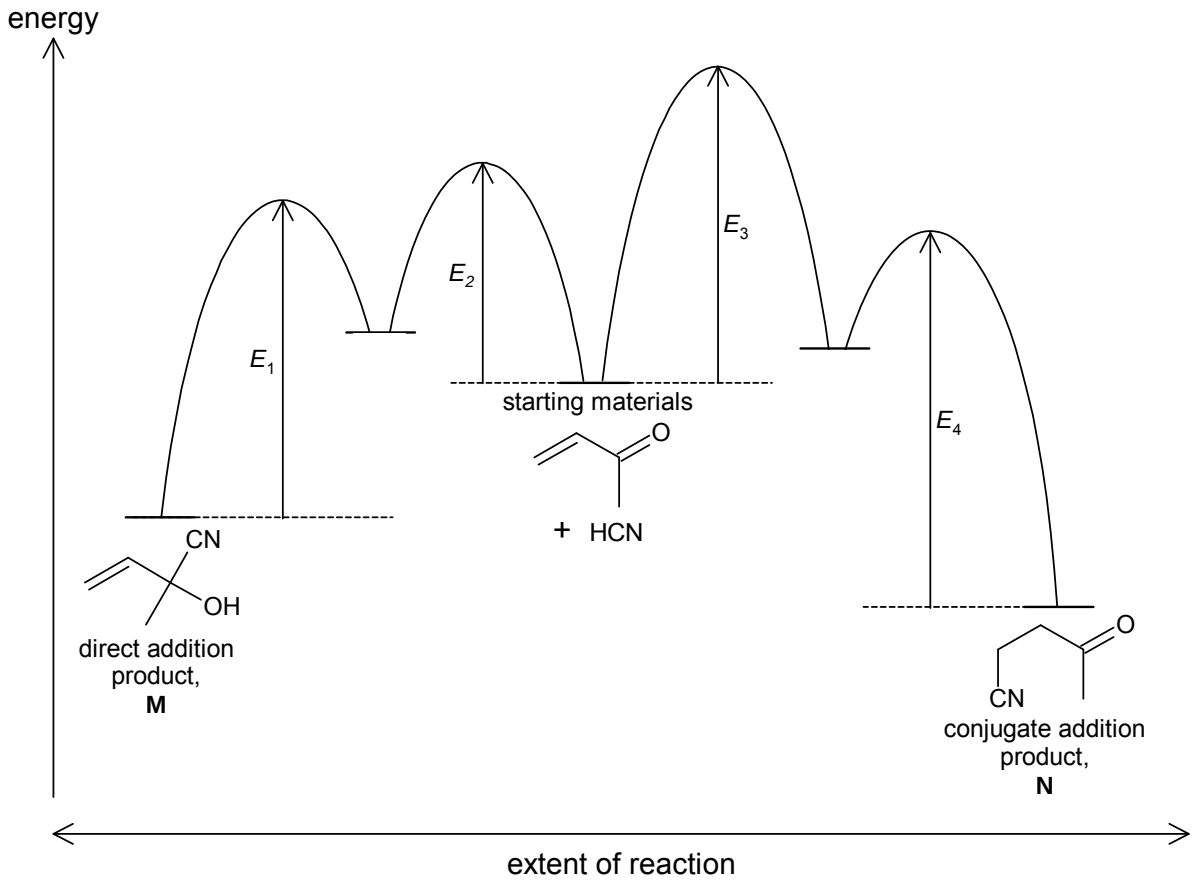
**D** The distribution of energies will be given by curve **X** and the activation energy by value $E_a$.

**9** HCN can add to butenone in two ways to form products **M** and **N**.




**M** butenone **N**

The energy profile for the reaction is shown below.




Which of the following statements is **true** about this energy profile?

**A** Four possible intermediates are formed during the reaction between butenone and HCN.

**B** At lower temperatures, the formation of **M** is favoured, while at higher temperatures, **N** is favoured.

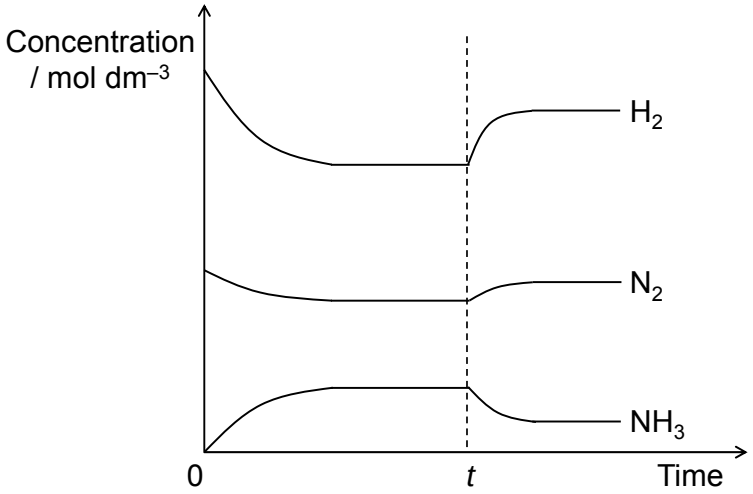
**C** If $E_1 \approx E_3$, **N** is re-converted back to butenone as easily as **M** does.

**D** **N** is formed more quickly than **M**.

**10** A system containing a nitrogen and hydrogen gas mixture is allowed to reach equilibrium.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H < 0$$

At time *t*, a change is made to the conditions inside the reaction vessel. The changes in concentrations with time of the three compounds in the mixture are represented by the graphs below.




Which of the following changes, made at time *t*, could have given these results?

**A** Temperature is increased.

**B** Volume of the reaction vessel is decreased.

**C** Ammonia is removed from the equilibrium mixture.

**D** Argon is introduced into the reaction vessel at constant volume.

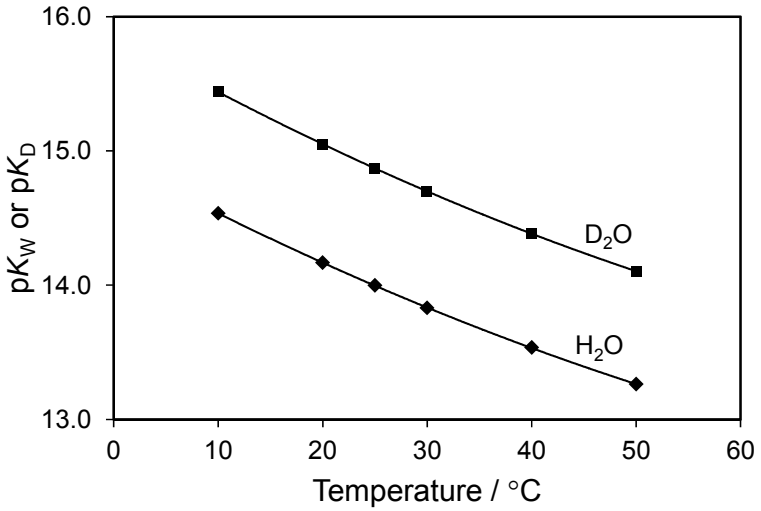
**11** The molecule of deuterium oxide, otherwise known as 'heavy water', consists of an oxygen atom bonded to two atoms of the hydrogen isotope, deuterium, $^{2}_{1}D$ .

Like water, $H_2O$, pure $D_2O$ is weakly ionised.

$$2D_2O \rightleftharpoons D_3O^+ + OD^-$$

For $D_2O$, we can use the term $K_D$ instead of $K_W$.

The following graphs show how the values $K_W$ of $H_2O$ and $K_D$ of $D_2O$ vary with temperature.




Which of the following deductions is **correct**?

**A** The enthalpy change of ionisation for both $H_2O$ and $D_2O$ is negative.

**B** The degree of ionisation for $D_2O$ is smaller than that for $H_2O$.

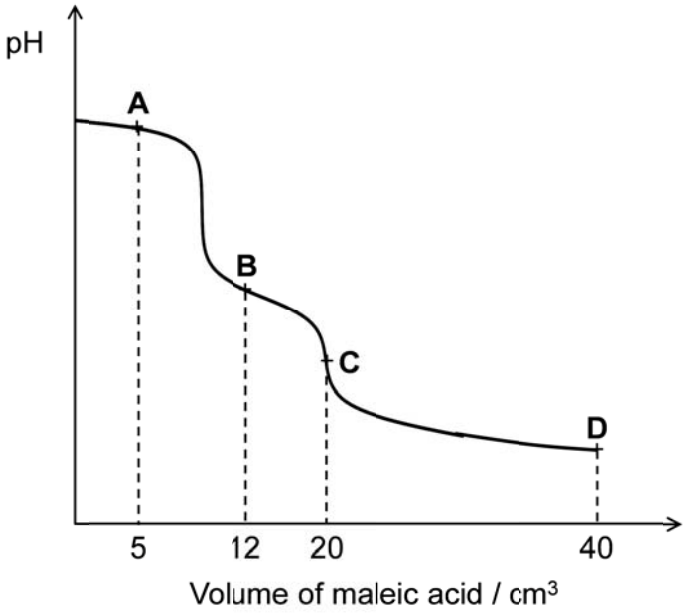
**C** Both $[OH^-]$ in $H_2O$ and $[OD^-]$ in $D_2O$ decrease with increasing temperature.

**D** The O–D bond is weaker than the O–H bond.

**12** Maleic acid, $HO_2CHCHCO_2H$, is a weak acid which ionises in stages.

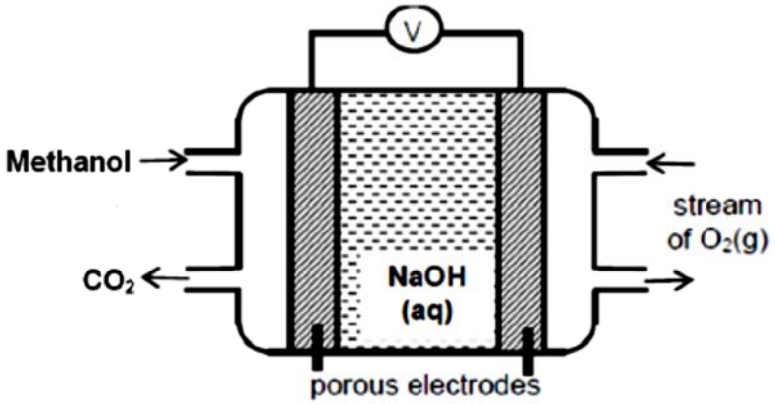
$$HO_2CHCHCO_2H \xrightarrow[pK_{a1}]{-H^+} HO_2CHCHCO_2^- \xrightarrow[pK_{a2}]{-H^+} {}^-O_2CHCHCO_2^-$$

When a solution of maleic acid is added gradually to 20.0 $cm^3$ of sodium hydroxide solution of the same concentration, the following titration curve is obtained.




At which point on the titration curve is the mixture **most** able to resist pH change upon addition of a small amount of aqueous acid or base?

**13** Scientists are discovering that microbial fuel cell (MFC) technology is a viable alternative to power generation in remote locations. An example of an MFC is as shown below.




Which of the following statements about the above MFC is **not** correct?

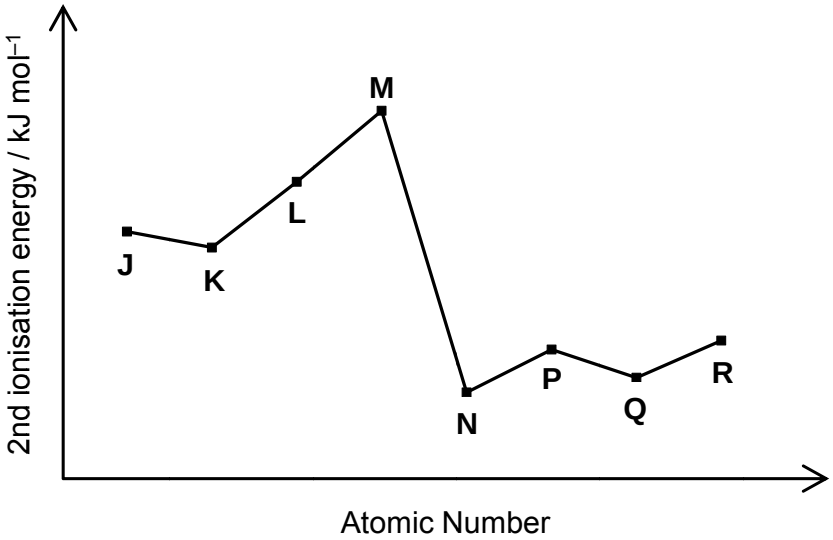
**A** Electrons flow from the right electrode to the left electrode.

**B** Methanol is oxidised in this reaction.

**C** The pH decreases at the anode.

**D** Porous electrodes are used to increase the rate of the reaction.

**14** The following graph shows the second ionisation energies of eight consecutive elements **J** to **R**, which have atomic numbers between 3 to 20 in the Periodic Table.




Which one of the following statements about the elements is **not** correct?

**A** **M** is possibly magnesium metal.

**B** Chloride of **Q** could be acidic.

**C** **L** is a noble gas.

**D** Hydroxide of **N** turns red litmus paper blue.

**15** Group II metals react readily with oxygen to form oxides.

When each of these oxides is added to water, which forms the **least** alkaline solution?

**A** SrO

**B** BaO

**C** MgO

**D** CaO

**16** Which of the following statements regarding halide ions and its compounds is **correct**?

**A** Reducing power of halides decreases down the group.

**B** A pungent smell can be detected when sodium iodide reacts with concentrated $H_2SO_4$.

**C** Sodium chloride gives a yellow solid when reacted with concentrated $H_2SO_4$.

**D** Silver bromide is more soluble than silver chloride.

**17** Which of the following species does **not** act as a ligand in the formation of complexes?

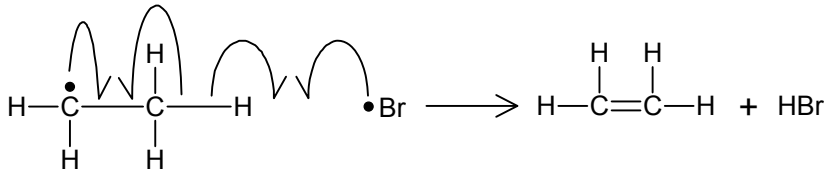
**A** $BH_3$

**B** $NH_3$

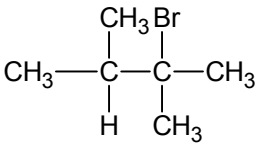
**C** $CN^-$

**D** $C_2O_4^{2-}$

**18** When heated with bromine, ethane undergoes free radical substitution. In a termination step, ethene can be formed when a radical like Br• abstracts a hydrogen atom from an ethyl radical.



In a similar reaction between the following bromoalkane and bromine, the free radical **R•** is formed by the loss of one hydrogen atom in one of the propagation steps.



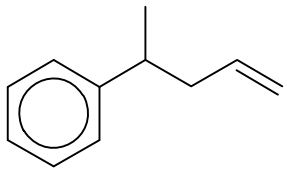
Two of these **R•** radicals react in a termination step to form an alkene.

$$\mathbf{R}\bullet + \mathbf{R}\bullet \rightarrow \text{alkene} + \mathbf{R}H$$

How many isomeric alkenes are theoretically possible?

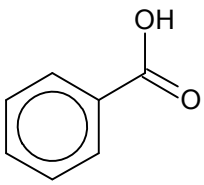
**A** 0 **B** 1 **C** 2 **D** 3

**19** What would most likely be the organic product formed when (pent–4–en–2–yl)benzene is reacted with cold, acidified $KMnO_4$?

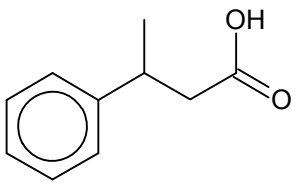


**(pent–4–en–2–yl)benzene**

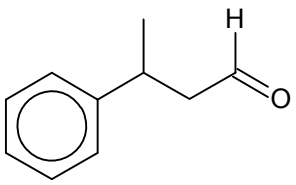
**A**



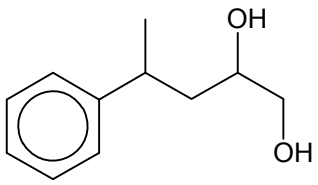
**C**



**B**



**D**



**20** An optically pure enantiomer of butan–2–ol was found to rotate plane–polarised light clockwise by 13.5°.

When an optically pure enantiomer of 2–bromobutane was reacted with aqueous sodium hydroxide under heating, the purified product obtained was found to rotate plane–polarised light clockwise by 5.5°.

Which of the following mechanisms could have taken place, assuming complete reaction?

**A** $S_N1$ only **B** $S_N2$ only

**C** Both $S_N1$ and $S_N2$ **D** Elimination only

**21** Separate samples of three organic halogen compounds, **Q**, **R** and **S**, are warmed with aqueous ethanolic silver nitrate and left to stand.

| $CH_3CH_2CH_2CH_2Br$ | $CH_3CH_2CH{=}CHBr$ | $CH_2{=}CHCH_2CH_2Br$ |
|---|---|---|
| **Q** | **R** | **S** |

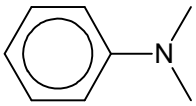
Which samples will yield a cream precipitate of silver bromide?

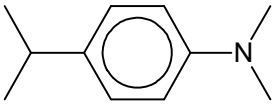
**A** **Q** only

**B** **Q** and **R**

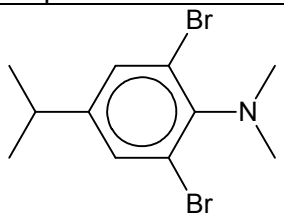
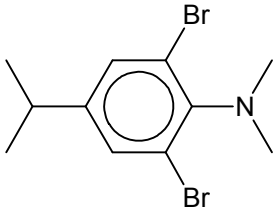
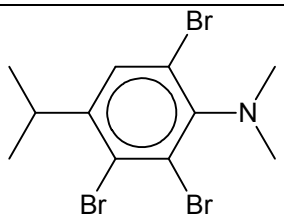
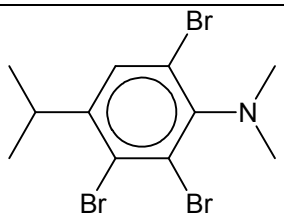
**C** **Q** and **S**

**D** None of the samples will yield a precipitate.

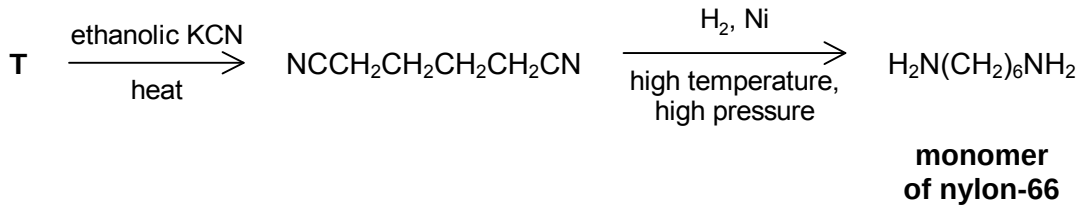
**22** Given that  has the same reactivity as phenylamine, what would be observed and what could be formed when compound **P** is added to bromine dissolved in an organic solvent?



**P**

| | observation | product formed |
|---|---|---|
| **A** | Reddish brown bromine is decolourised. |  |
| **B** | Reddish brown bromine is decolourised with the formation of white precipitate. |  |
| **C** | Reddish brown bromine is decolourised. |  |
| **D** | Reddish brown bromine is decolourised with the formation of white precipitate. |  |

**23** The reaction scheme below outlines the synthesis of one of the monomers of nylon–66 from compound **T**.



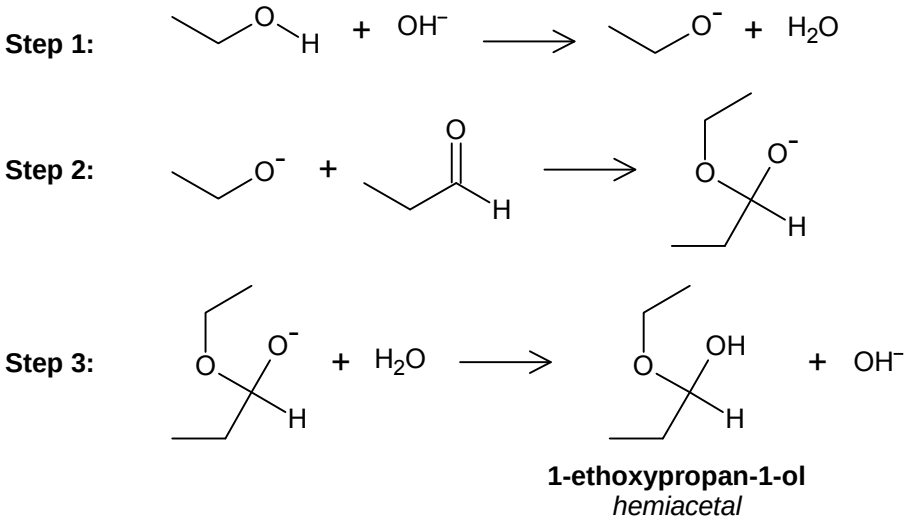

Which compound could be **T**?

**A** $BrCH_2CH_2CHClCH_3$ **B** $BrCH_2CH_2CH_2CH_2Cl$

**C** $HOCH_2CH_2CH_2CH_2Br$ **D** $HCOCH_2CH_2CHO$

**24** 1–Ethoxypropan–1–ol is an example of a hemiacetal, an organic compound which has an alcohol and an ether attached to the same carbon atom. It is formed when propanal reacts with ethanol in the presence of a catalyst.

The reaction follows the mechanistic pathway below.




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

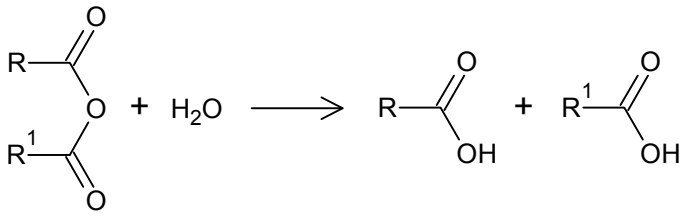
**A** **Step 2** is an electrophilic addition reaction across the C=O bond.

**B** The role of water in **Step 3** may be taken over by ethanol.

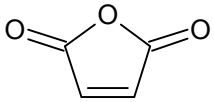
**C** KOH can be used as a catalyst for this reaction.

**D** The hydroxide ion acts as a base in **Step 1**.

**25** An acid anhydride is a carboxylic acid derivative that undergoes hydrolysis in water similar to acyl chlorides and esters. A mixture of carboxylic acids is produced in the case of the anhydride.



Based on the information above, which of the following can be deduced when maleic anhydride undergoes hydrolysis in the presence of water labelled with the $^{18}O$ isotope?



**maleic anhydride**

**A** Two carboxylic acid molecules are produced for every molecule of maleic anhydride.

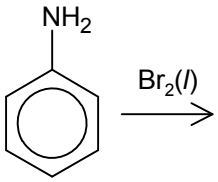
**B** The hydrolysis of maleic anhydride requires an acid or a base catalyst.

**C** A C–$^{16}O$ bond is stronger than a C–$^{18}O$ bond.

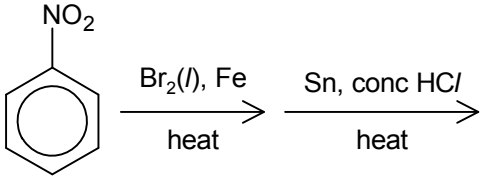
**D** All molecules in the product mixture are labelled with the $^{18}O$ isotope.

**26** Which of the following reaction schemes produces 3–bromophenylamine in the highest yield?

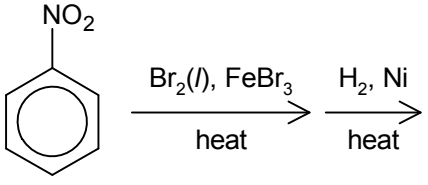
**A**



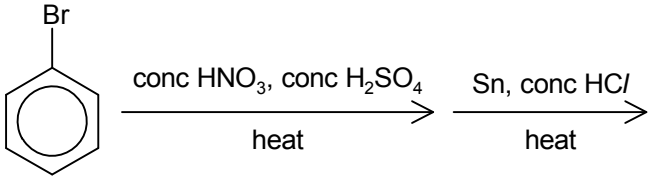
**B**



**C**



**D**



**27** Which one of the following statements regarding amines and amides is **true**?

**A** The melting point of ethanamide ($M_r$ = 59.0) is higher than that of trimethylamine ($M_r$ = 59.0) due to the hydrogen bonding present in ethanamide.

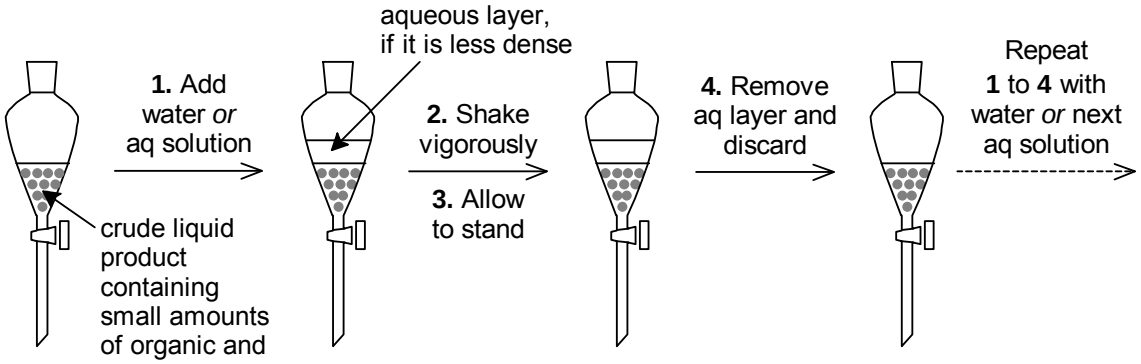
**B** Hydrogen bonds can form between molecules of any amine, and between molecules of any amide.

**C** Amides are more basic than phenylamine.

**D** Both amines and amides can form salts with dilute hydrochloric acid at room temperature.

**2 8** After an organic synthesis reaction, a crude liquid product may contain organic and inorganic impurities, and must be washed in a separating funnel with successive volumes of aqueous solutions or distilled water. These impurities are removed from the organic layer based on their different solubilities or reactions with the aqueous layer.

A typical wash procedure is as follows.




In an experiment, a student synthesised liquid 1–iodobutane by heating a mixture of butan–1–ol, red phosphorus and powdered iodine under reflux. He correctly concluded that his crude product contained small amounts of unreacted butan–1–ol and iodine, and decided to use distilled water and the following solutions to perform the washing.

| solution | possible reactions during washing |
|---|---|
| $Na_2S_2O_3$(aq) | • $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$<br>• $Na_2S_2O_3 + 2H^+ \rightarrow 2Na^+ + H_2O + S + SO_2$ |
| $Na_2CO_3$(aq) | • $Na_2CO_3 + 2H^+ \rightarrow 2Na^+ + H_2O + CO_2$ |
| conc HC*l* | • $CH_3(CH_2)_3OH + HCl \rightarrow CH_3(CH_2)_3OH_2^+Cl^-$ |

Which wash sequence should he adopt to remove the impurities present in crude 1–iodobutane?

**A** water → conc HC*l* → $Na_2S_2O_3$(aq) → $Na_2CO_3$(aq) → water

**B** water → $Na_2S_2O_3$(aq) → conc HC*l* → $Na_2CO_3$(aq) → water

**C** water → conc HC*l* → $Na_2CO_3$(aq) → $Na_2S_2O_3$(aq) → water

**D** water → $Na_2S_2O_3$(aq) → $Na_2CO_3$(aq) → conc HC*l* → water

**29** *Haemoglobin* is a protein found in red blood cells and is responsible for giving blood its characteristic red colour. Its role is to transport oxygen from respiratory organs to the rest of the body.

Which one of the following statements is **true** about the *haemoglobin* molecule?

**A** The *haem* molecule is an amino acid that is part of the polypeptide backbone of *haemoglobin*.

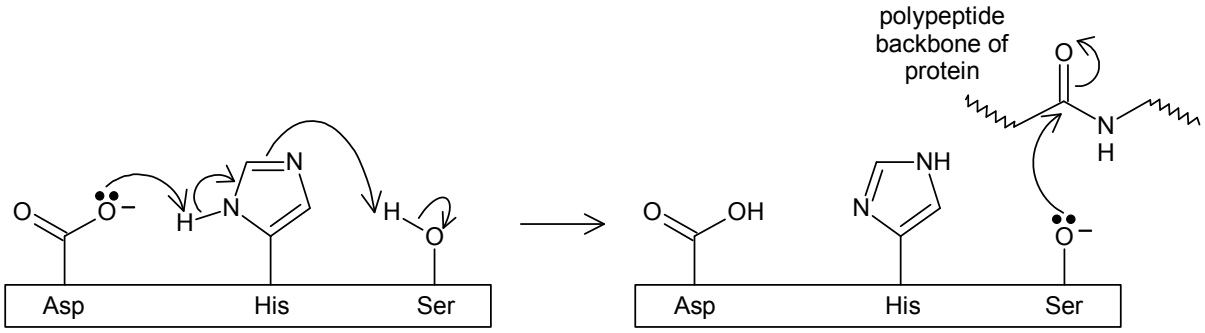
**B** *Haemoglobin* absorbs wavelengths corresponding to red light in the visible region.

**C** Constituent amino acids condense to form a single polypeptide chain which then folds to give the final shape of the *haemoglobin* molecule.

**D** Both $\Delta H$ and $\Delta S$ for the formation of *haemoglobin* from constituent amino acids are negative.

**30** *Chymotrypsin* is a digestive enzyme responsible for catalysing the hydrolysis of certain proteins in the small intestine.

The active site of *chymotrypsin* contains three main amino acids: His, Asp and Ser. The diagram below shows the first stage of the mechanism of the action of *chymotrypsin*.




With reference to this mechanism, which of the following **best** explains why the action of *chymotrypsin* would be inhibited if the pH was too low?

**A** All the nitrogen atoms in His will be protonated such that His is no longer able to accept a lone pair of electrons from Asp.

**B** Low pH does not affect the active sites of *chymotrypsin*, but instead hydrolyses the peptide bonds in the protein.

**C** The carboxylate ion group in Asp will be protonated.

**D** At low pH, Ser functions as an acid instead of His.

## Section B

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

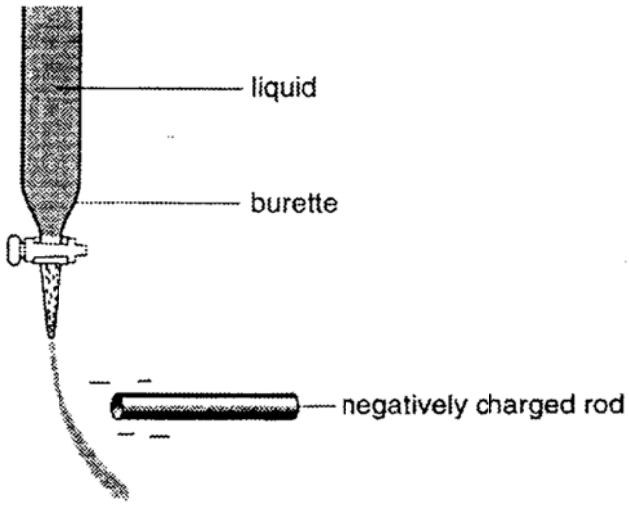
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements which you consider to be correct).

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 |

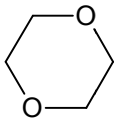
No other combination of statements is used as a correct response.

**31** The diagram shows a liquid flowing from a burette and a charged rod being brought near the flow.



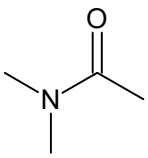

Which liquids would be deflected as shown?

**1**




**2**


**3**

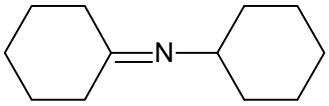


The responses **A** to **D** should be selected on the basis of

| 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.

**32** Which of the following statements about the structure of compound **V** are **correct**?



**V**

**1** **V** is polar.

**2** All carbon atoms in **V** lie on the same plane.

**3** The C–N–C bond angle is 180°.

**33** The diagram illustrates the energy changes of a set of reactions.


Which of the following can be deduced from this diagram?

**1** The first electron affinity of **X** is –342 kJ $mol^{-1}$.

**2** The enthalpy change for the transformation **X**(g) → $\mathbf{X}^-$(aq) will be exothermic.

**3** The enthalpy change for the reaction ½$\mathbf{X}_2$(standard state) → **X**(g) is –112 kJ $mol^{-1}$.

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

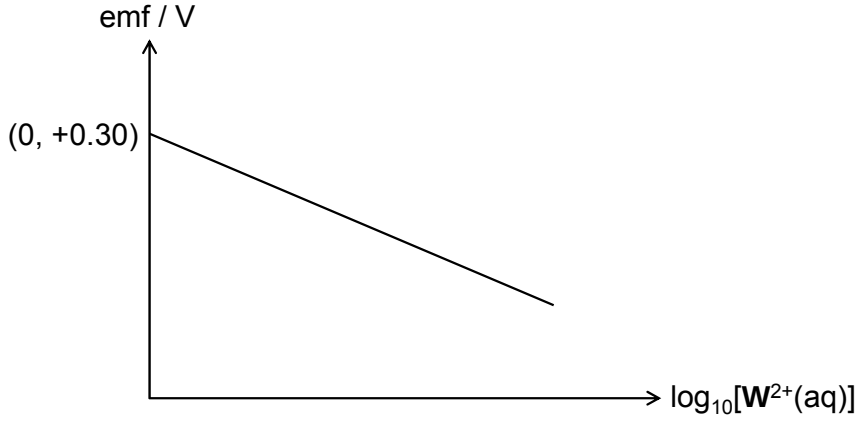
| A | B | C | D |
|---|---|---|---|
| **1**, **2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

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

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

The graph below shows the variation in electromotive force (emf) of an electrochemical cell with $\log_{10}$ [$\mathbf{W}^{2+}$(aq)] at 298 K.

$$\mathbf{W}(s) \mid \mathbf{W}^{2+}(aq) \,||\, Sn^{2+}(aq, 1 \text{ mol dm}^{-3}) \mid Sn(s)$$




Which statements about this cell are **true**?

**1** Sn(s) is the cathode.

**2** The standard electrode potential of the $\mathbf{W}^{2+}$(aq) | **W**(s) half-cell is –0.44 V.

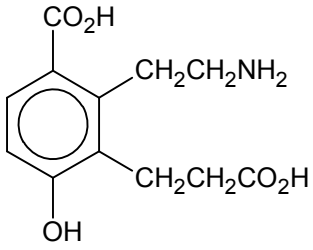
**3** When measured against the $Sn^{2+}$(aq) | Sn(s) half-cell under standard conditions, the electrode potential of the $\mathbf{W}^{2+}$(aq) | **W**(s) half-cell is –0.30 V.

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 |

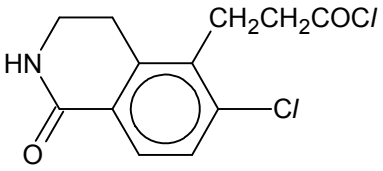
No other combination of statements is used as a correct response.

**35** Which of the following products could be formed when compound **X** reacts with $PCl_5$ at room temperature?

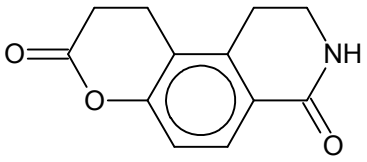



**X**

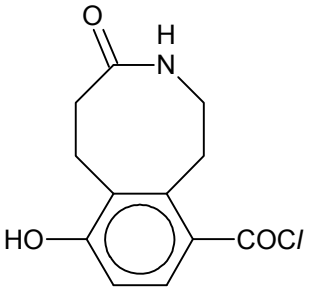
**1**




**2**




**3**

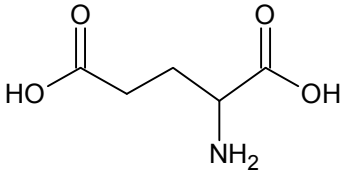
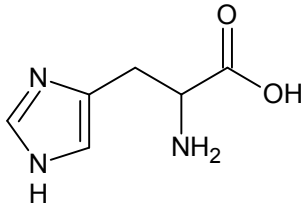


The responses **A** to **D** should be selected on the basis of

| 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.

**36** Consider the following amino acids and their associated $M_r$ and p$K_a$ values.

| amino acid | $M_r$ | p$K_a$ | | |
|---|---|---|---|---|
| | | $\alpha$–$CO_2H$ | $\alpha$–$NH_2$ | side–chain |
|  **glutamic acid** | 147 | 2.2 | 9.7 | 4.3 |
|  **histidine** | 155 | 1.8 | 9.2 | 6.0 |

Which statements are **correct** in a gel electrophoresis separation of the two amino acids?

**1** The zwitterions of both amino acids each have their positive ends at the $\alpha$–$NH_2$ group and the negative ends at the $\alpha$–$CO_2H$ group.

**2** At pH 6.0, glutamic acid migrates more quickly towards the anode than histidine does towards the cathode.

**3** At the pH that glutamic acid remains stationary, histidine migrates towards the cathode.

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.

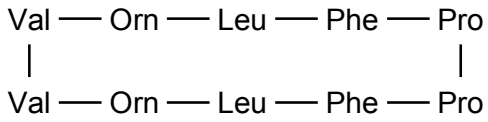
**37** *Gramicidin S* is a cyclic polypeptide with antibiotic properties. It is made up of two identical pentapeptides, Val–Orn–Leu–Phe–Pro, bonded together.

Which of the following statements about *gramicidin S* are **true**?

**1** Amino acids are produced when *gramicidin S* is heated in a solution of hydrochloric acid.

**2** 10 molecules of water are lost for every molecule of *gramicidin S* formed from individual amino acids.

**3** One possible structure of *gramicidin S* is




**38** Which of these compounds can be oxidised by acidified potassium dichromate(VI) solution and also gives a brick red precipitate with Fehling's reagent?

**1** $CH_3CH_2CH_2CHO$

**2** $C_6H_5CHO$

**3** $(CH_3)_2C(OH)CH_2COCH_3$

**39** Which one of the following properties is **correct** for chlorine?

**1** It exists as a green yellowish gas.

**2** It can oxidise fluoride ions to fluorine.

**3** It does not have the ability to undergo disproportionation.

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

Rhodium and platinum are precious metals commonly used in catalytic converters as catalysts.

Which properties allow these precious metals to be used in the catalytic converters?

**1** They have high melting points.

**2** They have partially filled d–orbitals.

**3** They can form coloured compounds.