



HWA CHONG INSTITUTION
C2 Preliminary Examinations
Higher 2

CANDIDATE
NAME

CT GROUP

12S

CENTRE
NUMBER

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INDEX
NUMBER

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CHEMISTRY

9647/01

Paper 1 Multiple Choice

25 September 2013

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.

1. Enter your NAME (as in NRIC). _____

Write your **name**

2. Enter the SUBJECT TITLE. _____

3. Enter the PAPER NUMBER. _____

Write your **CT group**

4. Enter your CT GROUP. _____

5. Date. _____

6. Enter your NRIC NUMBER or
FIN NUMBER.

7. Now SHADE the corresponding
lozenge in the grid for
EACH DIGIT or LETTER

NRIC / FIN															
S	0	0	0	0	0	0	0	0	A	K	U				
F	1	1	1	1	1	1	1	1	B	L	V				
G	2	2	2	2	2	2	2	2	C	M	W				
T	3	3	3	3	3	3	3	3	D	N	X				
	4	4	4	4	4	4	4	4	E	O	Y				
	5	5	5	5	5	5	5	5	F	P	Z				
	6	6	6	6	6	6	6	6	G	Q					
	7	7	7	7	7	7	7	7	H	R					
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Write and
shade your
NRIC
or FIN number

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A, B, C** and **D**.

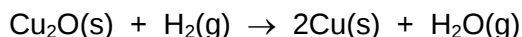
Choose the **one** you consider correct and record your choice in **soft pencil** on the OMS.

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

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

- 1 A mixture containing only aluminium oxide, Al_2O_3 , and copper(I) oxide, Cu_2O , weighs 2.02 g. When heated under a stream of hydrogen, Al_2O_3 is unchanged while Cu_2O is reduced to metallic copper and steam.

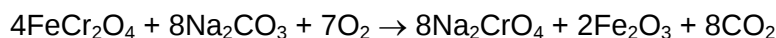


If the residue weighs 1.88 g, what is the percentage by mass of Cu_2O in the mixture?

[M_r : Al_2O_3 , 102.0; Cu_2O , 143.0]

- A** 12 % **B** 55 % **C** 59 % **D** 62 %

- 2 A constituent of wood preservative is manufactured by heating the ore chromite, FeCr_2O_4 , with sodium carbonate in air.



What are the changes in oxidation number of chromium and iron in this reaction?

	Change in oxidation number of chromium	Change in oxidation number of iron
A	+1	0
B	+2	0
C	+2	+1
D	+3	+1

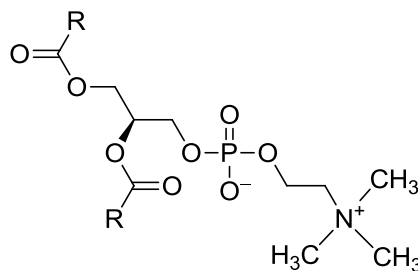
- 3 *Use of the Data Booklet is relevant to this question.*

Copper and magnesium are metals that are widely used in alloys. Each metal forms many compounds containing an M^{2+} ion.

Which statement concerning the atom and ion of these two elements is correct?

- A** Cu^{2+} ion has a smaller ionic radius than Mg^{2+} ion.
B Cu atom has a lower first ionization energy than Mg atom.
C Cu atom has two more occupied electron shells than Mg^{2+} ion.
D Cu^{2+} ion has a larger angle of deflection than Mg^{2+} ion when both ions are passed through the same electric field.

- 4 Lecithin is an emulsifier that is used in chocolate to give a smooth texture.



lecithin

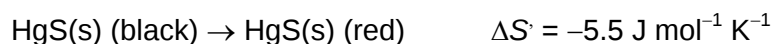
where R = long hydrophobic carbon chains

Which of the following statements about lecithin is correct?

- A It can form dispersion forces with non-polar molecules present in chocolate.
 - B It can form hydrogen bonds between its own molecules.
 - C All bond angles surrounding each carbon atom are 109° .
 - D It does not contain delocalized electrons.
- 5 A given mass of a diatomic gas was placed in a vessel of fixed volume $V \text{ cm}^3$ at a pressure $p \text{ atm}$ and temperature $T^\circ\text{C}$.

Assuming ideal behavior, which of the following changes would cause the density of the gas to double?

- A Cooling the gas to $\frac{1}{2} T^\circ\text{C}$.
 - B Adding a catalyst that causes the gas to dissociate into gaseous atoms at $T^\circ\text{C}$.
 - C Adding an equal mass of the same gas into the same vessel at $T^\circ\text{C}$.
 - D Connecting the vessel to an identical vessel containing the same mass of the diatomic gas at $T^\circ\text{C}$ and $p \text{ atm}$.
- 6 At all temperatures below 491°C , black HgS converts spontaneously to red HgS.



What is the standard enthalpy change for the conversion of black HgS to red HgS?

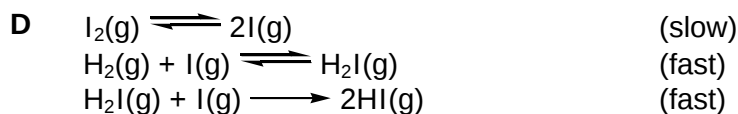
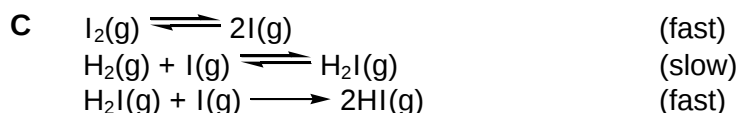
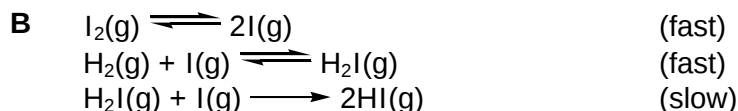
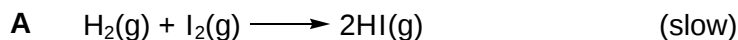
- A $+2.7 \text{ kJ mol}^{-1}$
- B $+4.2 \text{ kJ mol}^{-1}$
- C -2.7 kJ mol^{-1}
- D -4.2 kJ mol^{-1}

- 7 The rate equation for the reaction between hydrogen gas and iodine gas is given below.

$$\text{Rate} = k[\text{H}_2][\text{I}_2]$$

Kinetics studies have detected odd electron species in the course of the reaction.

Which of the following mechanisms is consistent with the information provided above?



- 8 The remains of an ancient building were recently uncovered in Rome. Its approximate age was determined by measuring the amount of radioactive ^{14}C that remains and it was found that 15.5% of the original amount of ^{14}C remains.

Assuming that ^{14}C decays via a first-order process and given that its half life is 5730 years, what is the approximate age of the ancient building?

- A** 1.1×10^4 years
B 1.5×10^4 years
C 1.7×10^4 years
D 2.3×10^4 years

- 9 1.00 mol of CH_4 , 2.00 mol of H_2S , 1.00 mol of CS_2 , and 2.00 mol of H_2 were placed in a 500 cm^3 reaction vessel at 960°C . The mixture was allowed to reach equilibrium according to the following equation.

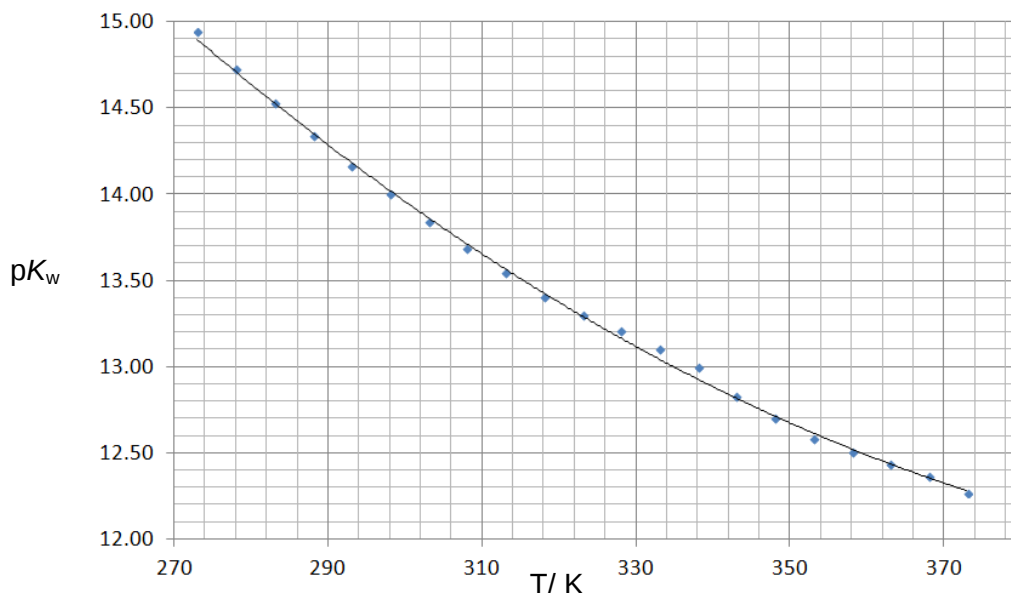


At equilibrium, the concentration of CH_4 was 1.12 mol dm^{-3} .

What is the value of the equilibrium constant, K_c , at 960°C ?

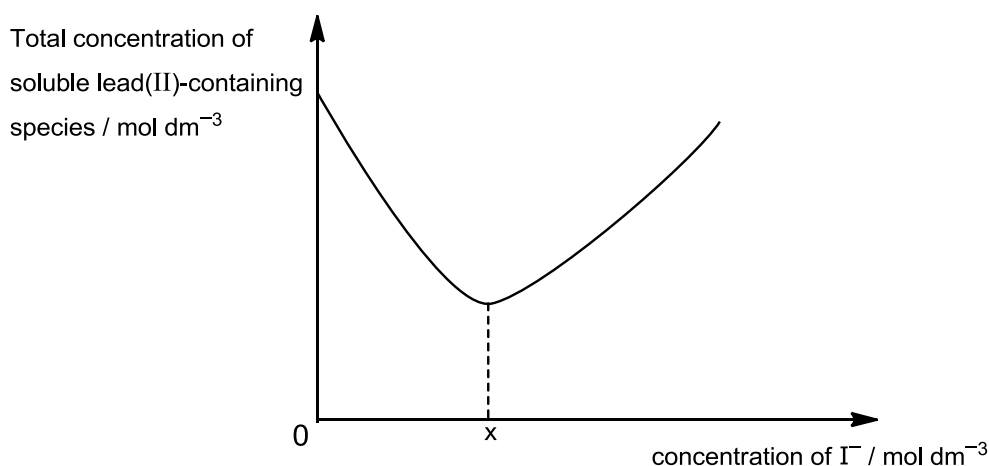
- A** 1.64×10^3 **B** 1.20 **C** 0.836 **D** 6.10×10^{-4}

- 10 The relationship between pK_w of H_2O and temperature is shown below.



Given that the bond energies of the oxygen–hydrogen and oxygen–deuterium bond are 462 kJ mol^{-1} and 466 kJ mol^{-1} respectively, which of the following statements is **incorrect**? [Deuterium, $D = {}^2H$]

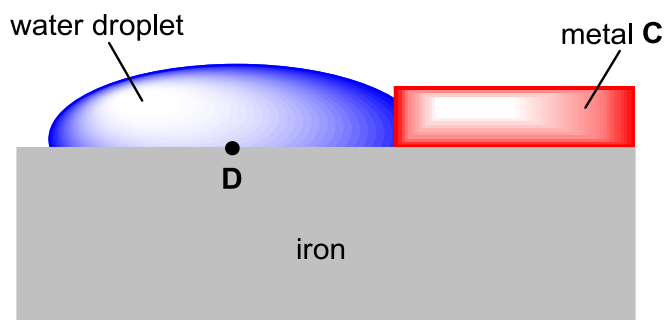
- A H_2O is neutral at 280 K.
 - B At 330 K, the pH of H_2O is approximately 6.55.
 - C The auto-ionisation of H_2O is an endothermic reaction.
 - D The graph for D_2O lies below the graph for H_2O .
- 11 The reaction between $Pb^{2+}(aq)$ and $I^{-}(aq)$ was investigated. The graph below shows the total concentration of soluble lead(II)-containing species against the concentration of iodide ions.



Which of the following conclusions can be inferred from the graph above?

- A When $0 < [I^{-}] < x$, a lead(II) complex is being formed.
- B When $[I^{-}] > x$, solid lead(II) iodide dissolves.
- C When $[I^{-}] = x$, the amount of solid lead(II) iodide is at its minimum.
- D When $[I^{-}] = x$, the concentration of $Pb^{2+}(aq)$ is 0 mol dm^{-3} .

12 The diagram below shows the presence of a water droplet on a piece of iron, together with an unknown metal **C** which is incorporated into the iron piece to prevent it from corrosion.



Which of the following descriptions of the rusting of iron is correct?

- A** The cathodic site is located at point **D** in the diagram.
- B** When metal **C** is zinc, iron behaves as the anode.
- C** When metal **C** is copper, corrosion of iron will not occur.
- D** The key reaction involving oxygen during rusting is $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^- \rightarrow 4\text{OH}^-$.

13 Which of the following chlorides gives a solution of the highest pH when added to water?

- A** NaCl **C** $\text{CH}_3\text{NH}_3\text{Cl}$
B MgCl_2 **D** SiCl_4

14 Magnesium nitrate and barium nitrate were heated strongly in separate experiments.

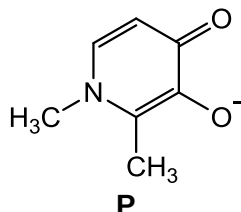
Which of the following information will distinguish the two compounds?

- A** Colour of the residual solid
- B** Solubility of the residual solid in water
- C** Colour of the gas evolved
- D** Whether the gas evolved rekindles a glowing splint

15 Which of the following trends concerning halogens and their compounds is correct?

- A** The boiling point of the hydrogen halides increases in the order $\text{HF} < \text{HCl} < \text{HBr} < \text{HI}$.
- B** The thermal stability of the hydrogen halides increases in the order $\text{HF} < \text{HCl} < \text{HBr} < \text{HI}$.
- C** The reducing power of the halide ions increases in the order $\text{F}^- < \text{Cl}^- < \text{Br}^- < \text{I}^-$.
- D** The reactivity of the halogens with hydrogen increases in the order $\text{F}_2 < \text{Cl}_2 < \text{Br}_2 < \text{I}_2$.

- 16 A neutral, red, octahedral complex is formed when ligand **P** is added to an aqueous solution of Fe^{3+} ions.



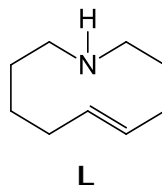
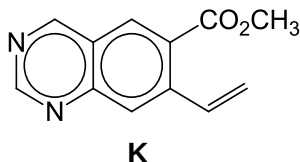
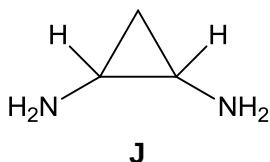
Which of the following statements is **incorrect**?

- A **P** is a stronger ligand than water.
 - B **P** acts as a tridentate ligand in the complex.
 - C The coordination number of iron remains unchanged on adding **P**.
 - D The complex absorbs radiation in the blue-green region of the visible spectrum.
- 17 Titanium has the electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$.

Which one of the following compounds is **unlikely** to exist?

- A K_2TiO_4 B K_3TiF_6 C TiO D TiO_2

Refer to the three compounds, **J**, **K** and **L**, for Questions 18 and 19.



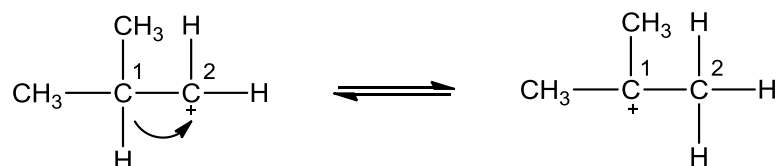
- 18 Which bond is **not** present in the compounds above?
- A a σ bond formed by sp^3 - sp^3 overlap between two C atoms in **J**
 - B a σ bond formed by sp^2 - sp^2 overlap between C and N atoms in **K**
 - C a σ bond formed by sp^3 - sp^2 overlap between two C atoms in **L**
 - D a σ bond formed by sp^2 - sp^2 overlap between C and N atoms in **L**
- 19 Which of the compounds exhibit geometric isomerism?

	J	K	L
A	Yes	Yes	Yes
B	Yes	No	Yes
C	No	No	Yes
D	No	No	No

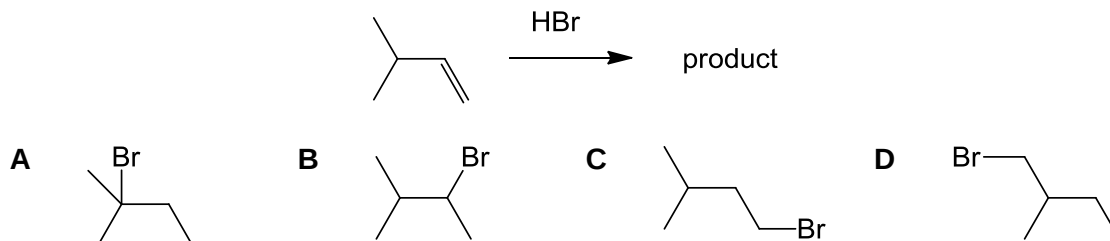
- 20** Methane is mixed with bromine gas in a gas jar. When exposed to uv light, a reaction occurs and a mixture of products is formed.

Which of the following statements shows that a free radical reaction has occurred?

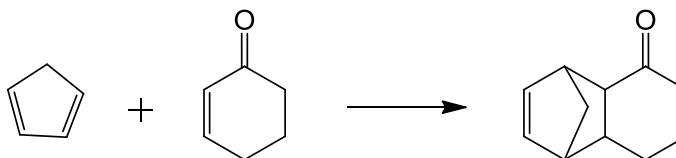
- A** The reaction requires uv light to initiate it.
B The reddish-brown bromine gas decolourises.
C Trace amounts of ethane are found in the mixture.
D Hydrogen bromide is a major product of the reaction.
- 21** A 1,2-hydride shift is a carbocation rearrangement in which a hydrogen atom in a carbocation migrates to an adjacent carbon atom to form a more stable carbocation.



Using the information above, which compound is the major product of the following reaction?



- 22** The Diels-Alder reaction is an organic reaction whereby a conjugated diene reacts with a substituted alkene in a single step to form the product. A particular reaction is shown below.



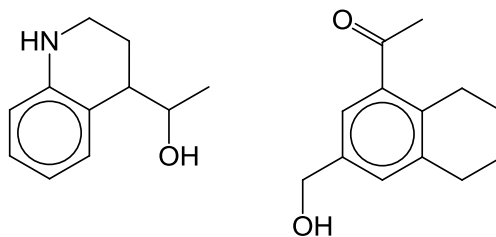
Three students made claims about this reaction.

X	It is an addition reaction to form a new cyclohexene ring.
Y	The overall order of the reaction is 2.
Z	One mole of the product requires one mole of hydrogen gas when heated in the presence of nickel catalyst for complete reaction.

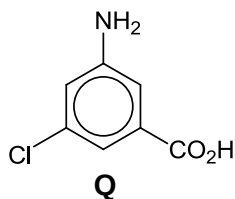
Which claims made by the students are correct?

- A** X and Y **B** Y and Z **C** X and Z **D** X, Y and Z

- 23 Which of the following reagents and conditions can be used to distinguish between the two compounds below?

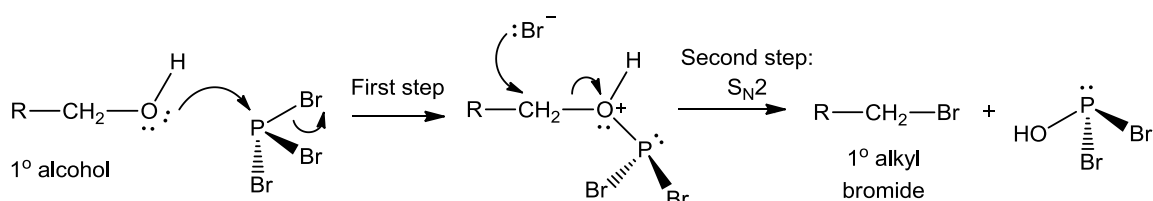


- A Aqueous bromine
 B Alkaline KMnO_4 , heat
 C Aqueous iodine, NaOH , warm
 D Tollens' reagent, warm
- 24 A student wishes to synthesise compound **Q** from benzene.



Which of the following routes would give the maximum yield of **Q**?

- A Alkylation $\rightarrow$ nitration $\rightarrow$ chlorination $\rightarrow$ reduction $\rightarrow$ oxidation
 B Nitration $\rightarrow$ alkylation $\rightarrow$ oxidation $\rightarrow$ chlorination $\rightarrow$ reduction
 C Alkylation $\rightarrow$ oxidation $\rightarrow$ nitration $\rightarrow$ reduction $\rightarrow$ chlorination
 D Chlorination $\rightarrow$ nitration $\rightarrow$ reduction $\rightarrow$ alkylation $\rightarrow$ oxidation
- 25 Alkyl bromides are commonly prepared by reacting an alcohol with phosphorus tribromide, PBr_3 . The reaction takes place in two steps, and the mechanism is shown below.



Which of the following statements is correct?

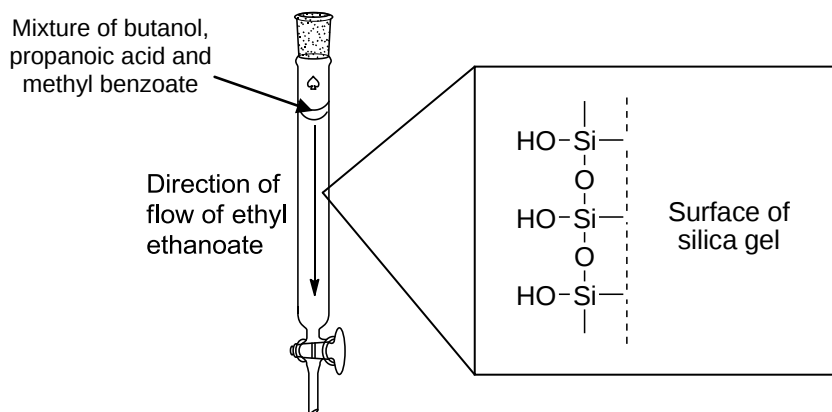
- A The rate of reaction for the first step is independent of the concentration of the primary alcohol.
 B Both steps involve the formation of a 5-coordinated transition state.
 C In the first step, the primary alcohol acts as a nucleophile.
 D Water can be used as a solvent in this reaction.

- 26 2-Methylpropanoic acid, also known as isobutyric acid, is found in many plants. In the laboratory, it may be synthesised from 1-bromopropane through a series of reactions.

Which set of reagents, used in sequential order, would be the most suitable for this synthesis?

- A aqueous KOH, acidified KMnO_4
 B aqueous KOH, PCl_5 , ethanolic KCN, dilute HCl
 C ethanolic KOH, HBr , ethanolic KCN, dilute H_2SO_4
 D ethanolic KOH, HBr , HCN with trace KCN, dilute HCl
- 27 A mixture of butanol, propanoic acid and methyl benzoate can be separated using column chromatography.

This is done by packing a glass column with silica gel, and gently adding the mixture of compounds to the top of the silica. Ethyl ethanoate is then allowed to flow through the packed column until each compound passes through the entire column. The rate at which each compound flows through the column depends on their affinity for silica gel.



Which option shows the relative rates at which butanol, propanoic acid and methyl benzoate flow through the column?

	Fastest		Slowest
A	Butanol	Propanoic acid	Methyl benzoate
B	Propanoic acid	Butanol	Methyl benzoate
C	Methyl benzoate	Butanol	Propanoic acid
D	Methyl benzoate	Propanoic acid	Butanol

- 28 Upon complete hydrolysis of a tetrapeptide **E**, only the following amino acids were obtained.

$\text{NH}_2\text{CH}(\text{CH}_2\text{OH})\text{CO}_2\text{H}$
serine ($M_r = 105.0$)

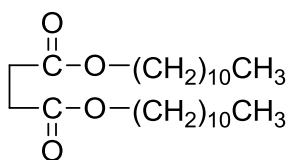
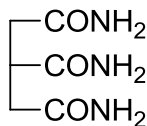
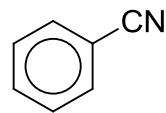
$\text{NH}_2\text{CH}(\text{CH}(\text{CH}_3)_2)\text{CO}_2\text{H}$
valine ($M_r = 117.0$)

$\text{NH}_2\text{CH}(\text{CH}_2\text{C}_6\text{H}_5)\text{CO}_2\text{H}$
phenylalanine ($M_r = 165.0$)

What could be the M_r of **E**?

- A 351.0 B 390.0 C 450.0 D 492.0

29 Experiments are carried out on three compounds, **F**, **G** and **H**.

**F****G****H**

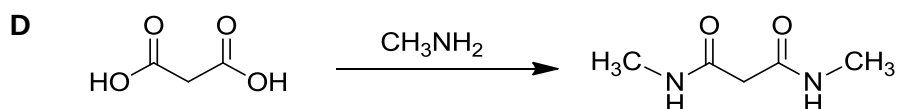
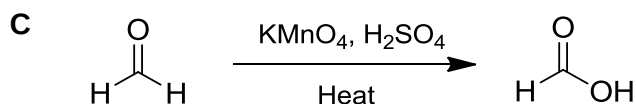
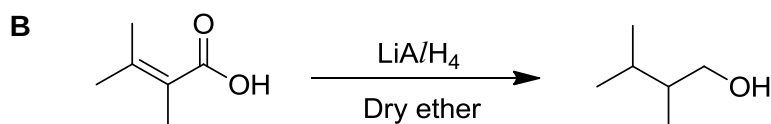
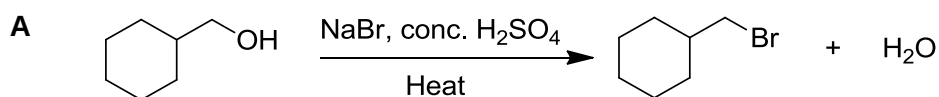
A sample of 0.01 mol of each compound is boiled under reflux with 50 cm³ of 1 mol dm⁻³ sodium hydroxide (an excess) until hydrolysis is complete and any ammonia produced is expelled from the solution. The excess NaOH is titrated in each case and is found to require 20 cm³, 30 cm³ and 40 cm³ of 1 mol dm⁻³ HCl for neutralization.

What sequence of compounds matches these results?

	20 cm ³	30 cm ³	40 cm ³
A	G	F	H
B	F	G	H
C	F	H	G
D	H	G	F

30 The reaction conditions for four different transformations are given below.

Which transformation has a set of conditions that is correct?



Section B

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

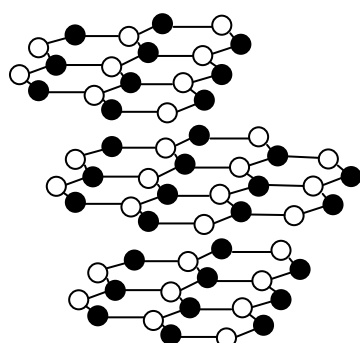
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements you consider to be correct).

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

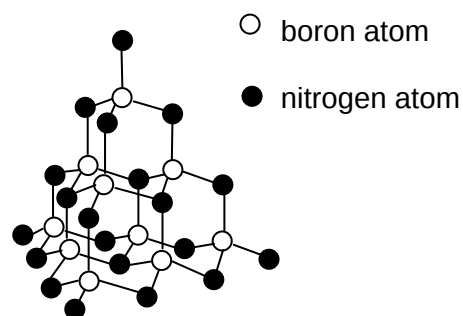
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

- 31** Boron nitride, BN, exists in two possible forms, hexagonal boron nitride and cubic boron nitride. The structure of hexagonal boron nitride and cubic boron nitride are similar to graphite and diamond respectively.



hexagonal boron nitride



cubic boron nitride

Which of the following statements are correct?

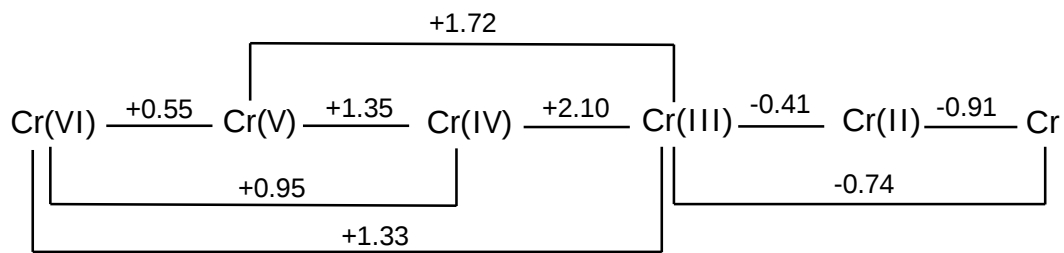
- 1 The layers in hexagonal boron nitride are held together by van der Waals' forces.
 - 2 There is dative bonding in cubic boron nitride.
 - 3 The boron-nitrogen bond in cubic boron nitride is shorter than that in hexagonal boron nitride.
- 32** For which of the following reactions does the value of ΔH° represent **both** a standard enthalpy change of combustion **and** a standard enthalpy change of formation?
- 1 $\text{P}_4(\text{s}) + 5\text{O}_2(\text{g}) \rightarrow \text{P}_4\text{O}_{10}(\text{s})$
 - 2 $\frac{1}{2}\text{N}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{NO}(\text{g})$
 - 3 $2\text{Mg}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{MgO}(\text{s})$

- 33 The table below shows some equilibrium constants involving HCl and HClO_4 .

Equations	K_c
$\text{HCl} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{Cl}^-$	∞
$\text{HCl} + \text{CH}_3\text{CO}_2\text{H} \rightleftharpoons \text{CH}_3\text{CO}_2\text{H}_2^+ + \text{Cl}^-$	2.8×10^{-9}
$\text{HClO}_4 + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{ClO}_4^-$	∞
$\text{HClO}_4 + \text{CH}_3\text{CO}_2\text{H} \rightleftharpoons \text{CH}_3\text{CO}_2\text{H}_2^+ + \text{ClO}_4^-$	1.3×10^{-5}

Which of the following statements could be inferred from the table above?

- 1 HClO_4 is a stronger acid than HCl .
 - 2 $\text{CH}_3\text{CO}_2\text{H}_2^+$ is a stronger acid than H_3O^+ .
 - 3 Liquid ammonia can be used to compare the acid strengths of HCl and HClO_4 because it is a stronger base than H_2O .
- 34 The Latimer diagram of an element provides a summary of the standard reduction potential data for that element. The Latimer diagram of chromium in acidic medium is shown below.



Which of the chromium species listed below will likely undergo disproportionation?

- 1 Cr(II)
 - 2 Cr(IV)
 - 3 Cr(V)
- 35 What would be observed when a small sample of P_4O_6 is added to some water containing a few drops of Universal Indicator?
- 1 The solid dissolves.
 - 2 The solution changes colour from blue to red.
 - 3 White fumes are evolved.
- 36 Use of the Data Booklet is relevant to this question.

Paper coated with starch and potassium iodide is commonly used as a test for unknowns during qualitative analysis. A positive test is indicated by the appearance of a dark blue colour on the paper.

Which solution gives a positive test when starch-iodide paper is dipped into it?

- 1 $\text{Cl}_2(\text{aq})$
- 2 $\text{FeCl}_3(\text{aq})$
- 3 Dilute HCl

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** To a limited amount of solid **M** in a beaker, solution **N** was added, followed by excess aqueous ammonia. A solid was observed to be present in the beaker.

Which of the following could **M** and **N** be?

	M	N
1	AgNO ₃	NaI
2	ZnCO ₃	dilute HNO ₃
3	CuO	dilute H ₂ SO ₄

- 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** CH₂(OH)CH₂CH₂CHO
- 2** C₆H₅CHO
- 3** (CH₃)₂C(OH)CH₂COCH₃

- 39** Ethanamide, CH₃CONH₂, is the simplest amide derived from ethanoic acid. It is used as a plasticizer and industrial solvent.

Which of the following statements regarding ethanamide are correct?

- 1** Electrons are delocalized across the atoms O, C and N.
- 2** Ethanamide dissolves in water to give an alkaline solution.
- 3** Ethanamide is a planar molecule.

- 40** Phenylamine can be synthesised from nitrobenzene in two steps. Tin and concentrated hydrochloric acid are used in the first step.

Which of the following statements are correct?

- 1** A water-soluble intermediate is formed in the process.
- 2** An excess of NaOH is added in the second step to liberate phenylamine.
- 3** Tin is regenerated.