



VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS
Higher 2

CHEMISTRY

9647/01

Paper 1 Multiple Choice

22 September 2016

1 hour

Additional Materials: Multiple Choice Answer Sheet
 Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

Write your NRIC/FIN number, name and CT group on the Answer Sheet.

There are **forty** questions. 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 choices in **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.

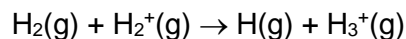
This document consists of **16** printed pages and **0** blank page.

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.*

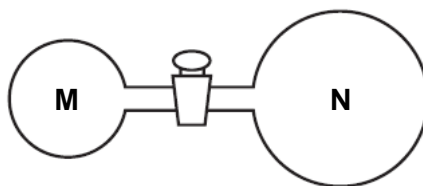
The most common ion–molecule reaction in gas clouds of the Universe is as shown.



What could be the composition of an H_3^+ ion?

	protons	neutrons	electrons
A	2	1	1
B	2	1	2
C	3	0	1
D	3	0	2

- 2 Two glass vessels **M** and **N** are connected by a closed valve.



M contains helium at 20 °C at a pressure of 1×10^5 Pa. **N** has been evacuated, and has three times the volume of **M**. In an experiment, the valve is opened and the temperature of the whole apparatus is raised to 100 °C.

What is the final pressure in the system?

- A** 3.18×10^4 Pa
B 4.24×10^4 Pa
C 1.25×10^5 Pa
D 5.09×10^5 Pa
- 3 The shell of a chicken's egg makes up 5% of the mass of an average egg. An average egg has a mass of 50 g.

Assume the egg shell is pure calcium carbonate.

How many complete chicken's egg shells would be needed to neutralise 50 cm³ of 2.0 mol dm⁻³ ethanoic acid?

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

- 4 Aluminium carbide, Al_4C_3 , reacts readily with aqueous sodium hydroxide. The two products of the reaction are NaAlO_2 and a hydrocarbon. Water molecules are also involved as reactants.

What is the formula of the hydrocarbon?

- A** CH_4 **B** C_2H_6 **C** C_3H_8 **D** C_6H_{12}

- 5 Which statement about the ammonium ion, NH_4^+ , is correct?

- A** All bond angles are 107° .
B Ammonium ions are formed when ammonia behaves as an acid.
C Ammonium ions are unreactive when heated with $\text{NaOH}(\text{aq})$.
D The bonds are all of the same length.

- 6 2-methylpropan-1-ol and butan-1-ol are structural isomers. 2-methylpropan-1-ol has a lower boiling point.

Which statement explains why the boiling point of 2-methylpropan-1-ol is lower than that of butan-1-ol?

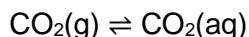
- A** 2-methylpropan-1-ol cannot form hydrogen bonds.
B 2-methylpropan-1-ol has weaker covalent bonds than butan-1-ol.
C 2-methylpropan-1-ol has weaker dispersion forces than butan-1-ol.
D 2-methylpropan-1-ol molecules have more surface area than butan-1-ol molecules.

- 7 The Gibbs free energy change, ΔG_{eq} , is related to the equilibrium constant, K_{eq} , by the following equation.

$$\Delta G_{\text{eq}} = -2.303 RT \lg K_{\text{eq}}$$

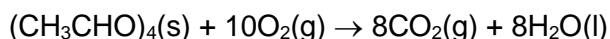
where R is the gas constant and T is the temperature in Kelvin.

Which statement about the following equilibrium is correct?



- A** Increasing the pressure at constant temperature makes ΔG_{eq} more negative.
B Adding a catalyst makes ΔG_{eq} more negative.
C The dissolution of CO_2 in water is spontaneous for all values of K_{eq} .
D At constant temperature, a shift in position of equilibrium to the right results in the same value of ΔG_{eq} .

- 8 Metaldehyde, $(\text{CH}_3\text{CHO})_4$, is used as a solid fuel for camping stoves. The equation for the complete combustion of metaldehyde is shown.



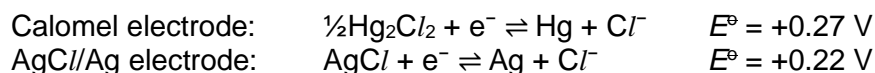
ΔH^\ominus_c = standard enthalpy change of combustion.

Which expression will give a correct value for the enthalpy change of formation of metaldehyde?

- A ΔH^\ominus_c metaldehyde – $(8\Delta H^\ominus_c$ carbon + $8\Delta H^\ominus_c$ hydrogen)
- B ΔH^\ominus_c metaldehyde – $(8\Delta H^\ominus_c$ carbon + $16\Delta H^\ominus_c$ hydrogen)
- C** $(8\Delta H^\ominus_c$ carbon + $8\Delta H^\ominus_c$ hydrogen) – ΔH^\ominus_c metaldehyde
- D $(8\Delta H^\ominus_c$ carbon + $16\Delta H^\ominus_c$ hydrogen) – ΔH^\ominus_c metaldehyde

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

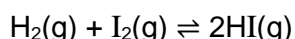
In research laboratories, the standard calomel reference electrode and the AgCl//Ag reference electrodes are often used in place of the standard hydrogen electrode (SHE). Their standard reduction potentials with respect to the SHE are shown below.



A half-cell containing Au^+/Au has a reduction potential of +1.56 V with respect to a calomel electrode.

Which of the following statements is correct?

- A** The reduction potential of the Au^+/Au half-cell with respect to the SHE is +1.83 V.
- B** The reduction potential of the Au^+/Au half-cell with respect to the AgCl//Ag electrode is +1.78 V.
- C** Ag has a higher tendency to be oxidised than H_2 .
- D** Hg_2Cl_2 has a lower tendency to be reduced than AgCl.
- 10 What is the volume of $0.100 \text{ mol dm}^{-3}$ NaOH that should be added to 20 cm^3 of $0.100 \text{ mol dm}^{-3}$ $\text{CH}_3\text{CO}_2\text{H}$ ($K_a = 1.8 \times 10^{-5} \text{ mol dm}^{-3}$) to form a buffer of pH 5.5?
- A** 15.0 cm^3 **B** 16.0 cm^3 **C** 17.0 cm^3 **D** 18.0 cm^3
- 11 $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ react according to the following equilibrium.



When 0.10 mol of $\text{H}_2(\text{g})$ and 0.10 mol of $\text{I}_2(\text{g})$ are heated in a sealed vessel at 600 K , 0.06 mol of HI was present at equilibrium.

What is the K_c value for the reaction at 600 K ?

- A** 0.184 **B** 0.360 **C** 0.735 **D** 1.36

- 12 After the Fukushima nuclear disaster in 2011, a radioactive isotope of iodine, ^{131}I , was detected at water purification plants in Japan. Radioactive decay is a first order reaction, and the half-life of radioactive ^{131}I is 8 days.

What is the mass of ^{131}I left after 40 days if the initial mass of ^{131}I was 15 g?

- A $\frac{15}{2 \times 5} \text{ g}$ B $\frac{15}{2^5} \text{ g}$ C $\frac{15}{2 \times 8} \text{ g}$ D $\frac{15}{2^8} \text{ g}$

- 13 Which of the following shows the properties of a Group II element? [$\Omega = \text{ohm}$]

	melting point / $^{\circ}\text{C}$	density / g cm^{-3}	electrical conductivity / $\Omega^{-1} \text{ m}^{-1}$
A	98	0.97	2.4×10^7
B	113	2.07	7.7×10^{-7}
C	649	1.74	2.2×10^7
D	1744	11.3	6.0×10^7

- 14 X, Y and Z are elements in the third period of the Periodic Table. The oxide of X is amphoteric, the oxide of Y is basic and the oxide of Z is acidic.

What is the order of increasing ionic radius for these three elements?

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

- 15 Sulfur is an element in the third period, Na to Ar, of the Periodic Table.

Which is the correct statement for sulfur?

- A Sulfur is the only element in this period which forms two acidic oxides.
 B Sulfur has the highest first ionisation energy of the elements in this period.
 C Sulfur is the only element in this period which can form compounds with variable oxidation states.
 D Sulfur is the only element in this period which can exist, at room temperature and pressure, as a simple molecule containing eight atoms.

- 16 Which anions containing chlorine are formed when chlorine is passed into hot aqueous potassium hydroxide?

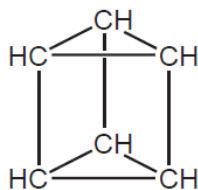
- A Cl^- and ClO^-
 B Cl^- and ClO_3^-
 C Cl^- and ClO_4^-
 D ClO^- and ClO_3^-

- 17 Four different complexes can be obtained by reacting aqueous cobalt(III) chloride with ammonia under various conditions. Different proportions of chloride are precipitated when each complex is treated with aqueous silver nitrate.

	empirical formula	colour of solid	number of moles of AgCl precipitated per mole of complex
I	$\text{CoCl}_3(\text{NH}_3)_6$	orange	3
II	$\text{CoCl}_3(\text{NH}_3)_5$	violet	2
III	$\text{CoCl}_3(\text{NH}_3)_4$	violet	1
IV	$\text{CoCl}_3(\text{NH}_3)_4$	green	1

Which of the following statements is correct regarding the four different complexes?

- A Only complexes III and IV have the coordination number of 6.
 B The cations in all four complexes have the same charge.
 C Ligands of complex I consists of both chloride and ammonia.
 D Complexes III and IV are stereoisomers.
- 18 In 1869 Ladenburg suggested a structure for benzene, C_6H_6 , in which one hydrogen atom is attached to each carbon atom.



Ladenburg structure

A compound $\text{C}_6\text{H}_4\text{Br}_2$ could be formed with the same carbon skeleton as the Ladenburg structure.

How many structural isomers would this compound have?

- A 2 B 3 C 5 D 6
- 19 Samples of the gases $\text{CH}_3\text{CH}_2\text{Cl}$ and Cl_2 are mixed together and irradiated with light.

Which of the following is **not** likely to be formed in the reaction?

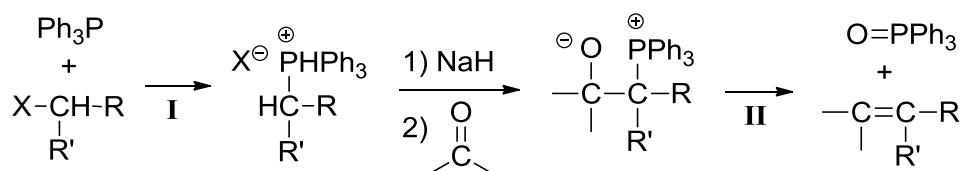
- A CH_3CHCl_2
 B $\text{CHCl}_2\text{CH}_2\text{Cl}$
 C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
 D $\text{CH}_2\text{ClCH}(\text{Cl})\text{CH}(\text{Cl})\text{CH}_3$

- 20 Compound **U** gives a positive test with Tollens' reagent and can be oxidised with acidified $\text{K}_2\text{Cr}_2\text{O}_7$ to form 3-methylbutanoic acid.

Compound **U** can be reduced by NaBH_4 to form compound **V** which reacts with ethanoyl chloride to form compound **W**.

What is the structure of compound **W**?

- A $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_3$
 B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OCOCH}_3)\text{CH}_3$
 C $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OCOCH}_3$
 D $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OCOCH}_3$
- 21 The Wittig reaction offers a highly versatile method to synthesise a wide variety of alkenes. The mechanism for the reaction is summarised as follows.



(Ph denotes a phenyl group, C_6H_5^-)

Which of the following correctly represents the type of reaction occurring in stages **I** and **II**?

	stage I	stage II
A	nucleophilic substitution	elimination
B	nucleophilic substitution	condensation
C	nucleophilic addition	elimination
D	nucleophilic addition	condensation

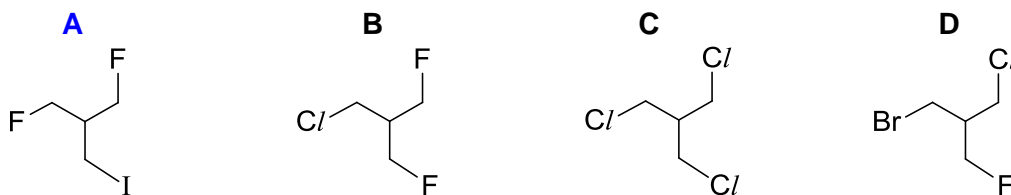
- 22 Which of the following can be used to distinguish between the two compounds?



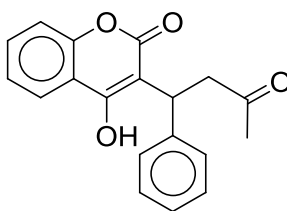
- A H_2 and Pd
 B $\text{Br}_2(\text{aq})$
 C warm Fehling's reagent
 D hot acidified $\text{K}_2\text{Cr}_2\text{O}_7$

- 23 The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?



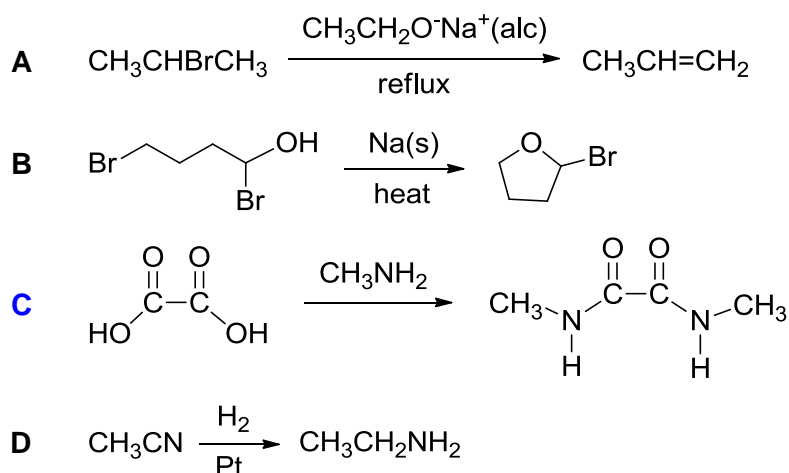
- 24 Warfarin ($M_r = 308$) is an oral anticoagulant that is used to prevent heart attacks, strokes and blood clots. The structural formula of warfarin is given below.



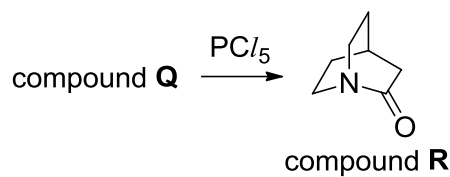
Which of the following statements about warfarin is correct?

- A** It has a total of 4 stereoisomers.
 - B** It reacts with CH_3COCl to form white fumes.
 - C** 1 mol of warfarin reacts with 1 mol of alcoholic potassium cyanide in the presence of heat.
 - D** 1 mol of warfarin reacts with 1 mol of hydrogen gas in the presence of nickel catalyst and heat.
- 25 The reaction conditions for four different transformations are given below.

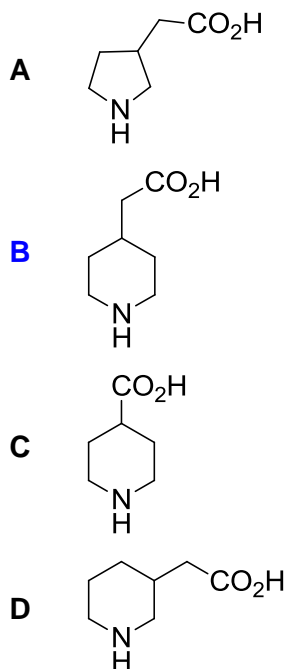
Which transformation has a set of reagents or conditions that is **not** correct?



- 26 Compound **R** is formed from compound **Q** as shown below.



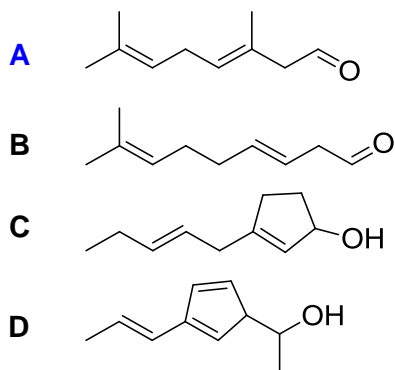
Which structure could be **Q**?



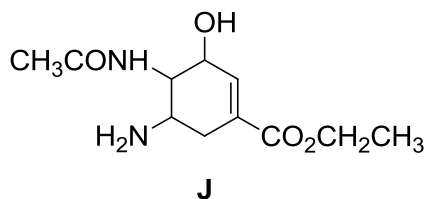
- 27 The reaction of compound **E** ($M_r = 152$) with hot acidified potassium manganate(VII) yields three products, **F**, **G** and **H**.

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

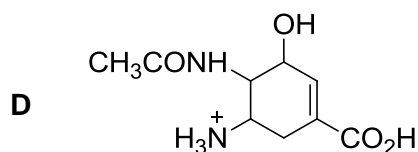
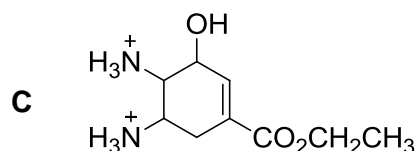
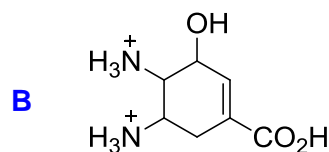
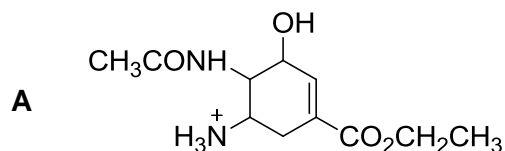
Which of the following shows the structure of compound **E**?



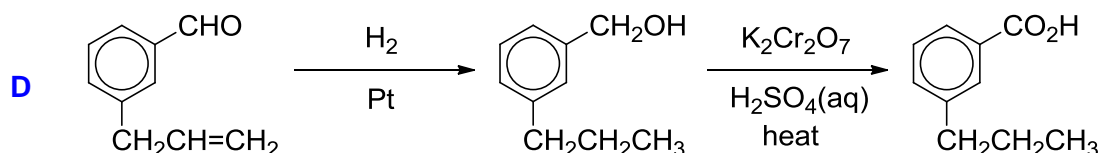
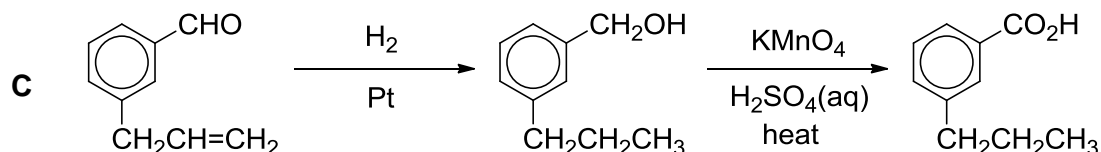
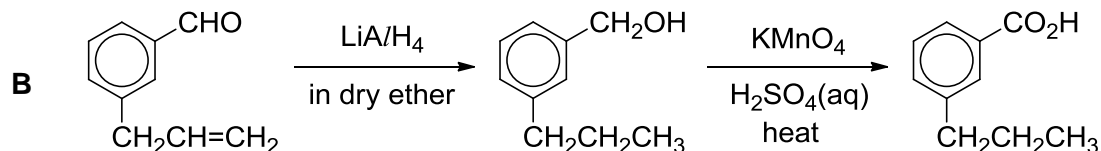
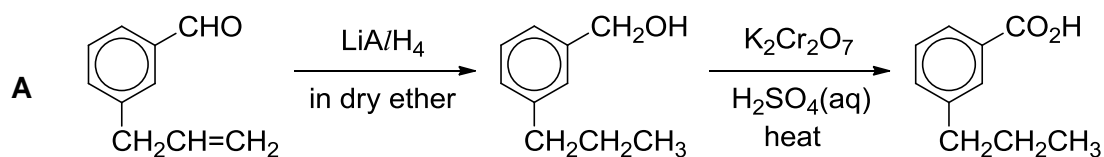
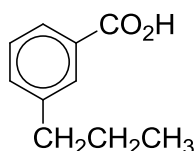
28 Compound **J** is a pharmaceutical drug.



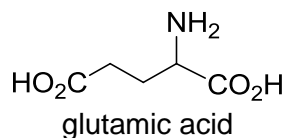
What is the species formed when compound **J** is heated with HCl(aq) ?



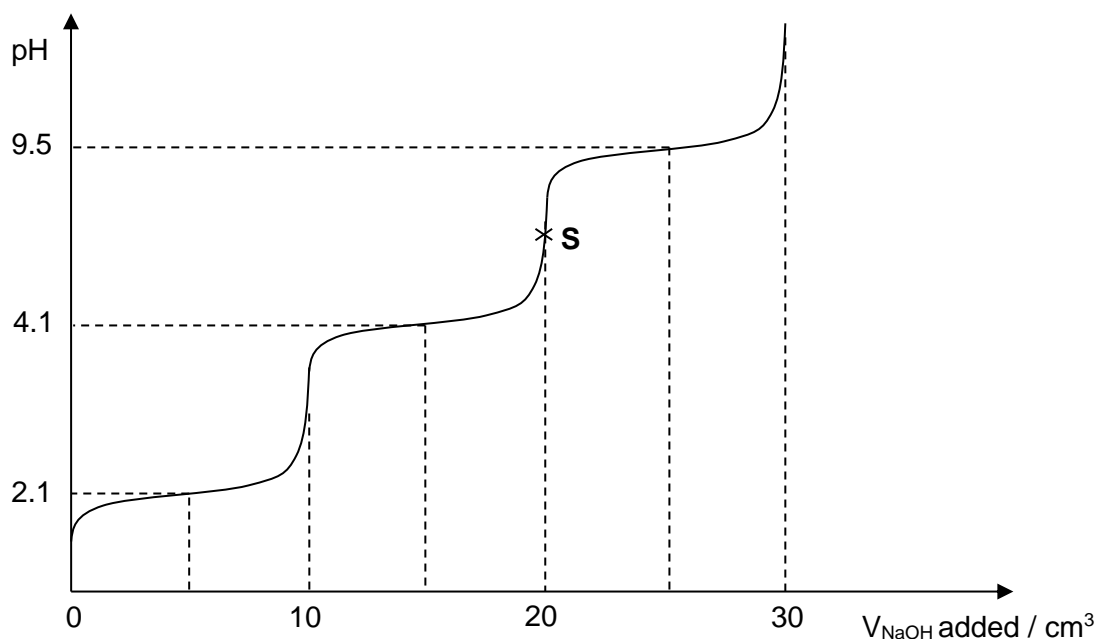
29 Which synthetic route will lead to the successful synthesis of the following product?



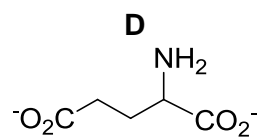
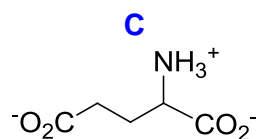
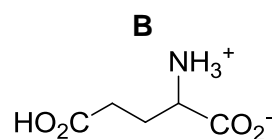
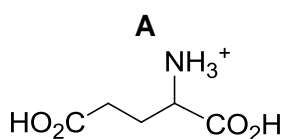
- 30 Soy sauce is produced by the fermentation of soy beans by the mould *Aspergillus oryzae*. The distinctive salty taste of the sauce is due to salts of glutamic acid formed during fermentation.



The pH–volume curve obtained when 30 cm³ of NaOH is added to 10 cm³ of the protonated form of glutamic acid of the same concentration is given below.



Which of the following is the major species present at point **S**?



Section B

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

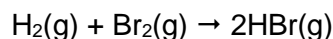
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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

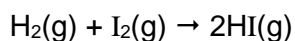
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

31 Hydrogen reacts with gaseous bromine to form hydrogen bromide



and with gaseous iodine to form hydrogen iodide.



For the first reaction, the rate equation is

$$\text{rate} = \frac{k_1 [\text{H}_2][\text{Br}_2]^{1.5}}{[\text{Br}_2] + k_2[\text{HBr}]}$$

For the second reaction, the rate equation is

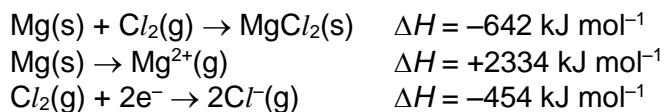
$$\text{rate} = k[\text{H}_2][\text{I}_2]$$

What can be deduced from this information only?

- 1** For the hydrogen / bromine reaction, the formation of HBr slows down the rate of the forward reaction.
- 2** Only the hydrogen / iodine reaction could be a single step reaction.
- 3** The mechanism of the hydrogen / bromine reaction involves free radicals.

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

Given the enthalpy changes of the following reactions.

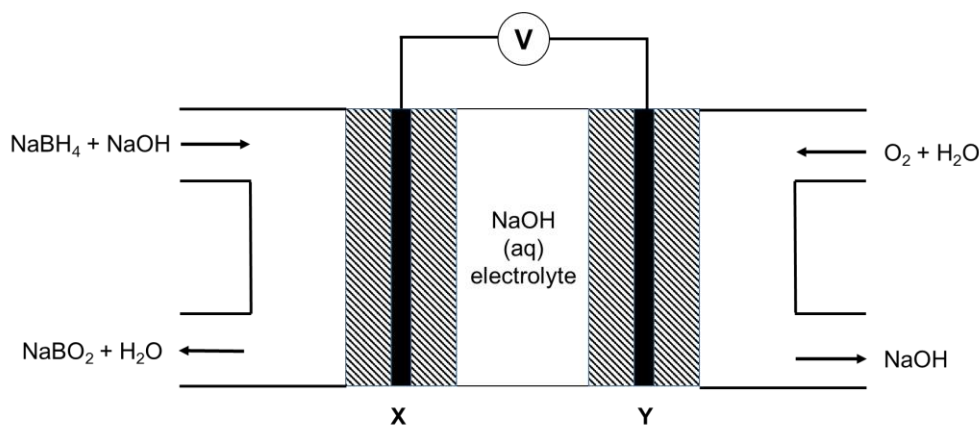


Which of the following statements are correct?

- 1 The enthalpy change of formation of $\text{MgCl}_2(\text{s})$ is -642 kJ mol^{-1} .
- 2 The enthalpy change of atomisation of Mg(s) is $+148 \text{ kJ mol}^{-1}$.
- 3 The electron affinity of Cl(g) is -698 kJ mol^{-1} .

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

The Direct Borohydride Fuel Cell (DBFC) is a type of alkaline fuel cell that uses NaBH_4 as the fuel and O_2 as the oxidant. A DBFC was set up under standard conditions according to the diagram below.



The electrode potential of the $\text{NaBH}_4/\text{NaBO}_2$ half-cell is given below.



Which of the following statements regarding the DBFC are correct?

- 1 The voltmeter will register a reading of $+1.64 \text{ V}$.
- 2 Electrode **X** is the anode and electrode **Y** is the cathode in the DBFC.
- 3 The BO_2^- ion produced at electrode **X** has a bond angle of 180° .

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 The K_{sp} values of three metal hydroxides are given in the table below.

metal hydroxide	K_{sp}
$\text{Ca}(\text{OH})_2$	$4.7 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$
$\text{Sn}(\text{OH})_2$	$5.4 \times 10^{-27} \text{ mol}^3 \text{ dm}^{-9}$
$\text{Cr}(\text{OH})_3$	$6.7 \times 10^{-31} \text{ mol}^4 \text{ dm}^{-12}$

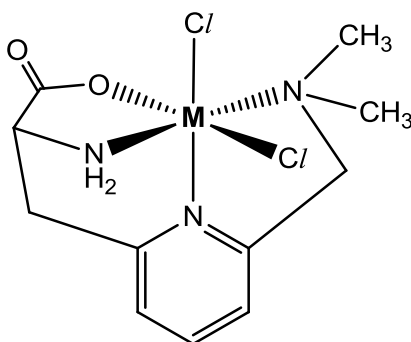
Which of the following statements are correct?

- 1** The concentration of OH^- in a saturated solution of $\text{Ca}(\text{OH})_2$ is $0.021 \text{ mol dm}^{-3}$.
- 2** $\text{Ca}(\text{OH})_2(\text{s})$ will be precipitated if equal volumes of $0.02 \text{ mol dm}^{-3} \text{ NaOH}(\text{aq})$ and $0.02 \text{ mol dm}^{-3} \text{ Ca}(\text{NO}_3)_2(\text{aq})$ are mixed together.
- 3** $\text{Cr}(\text{OH})_3$ has the lowest solubility amongst the three metal hydroxides.

35 Which of the following properties generally increase down Group II?

- 1** thermal stability of the iodate(V) salt, $\text{M}(\text{IO}_3)_2$
- 2** magnitude of the lattice energy of the oxide, MO
- 3** charge density of the M^{2+} ion

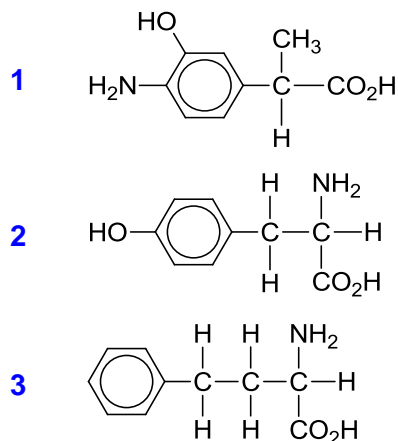
36 Which of the following statements regarding the metal complex below are correct?



- 1** The oxidation number of **M** in the complex is +3.
- 2** The coordination number of **M** in the complex is 6.
- 3** The complex contains a tetradentate ligand.

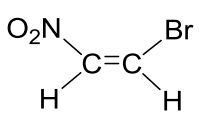
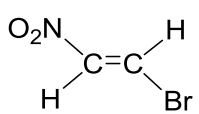
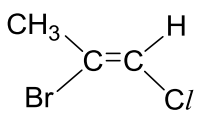
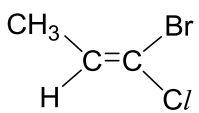
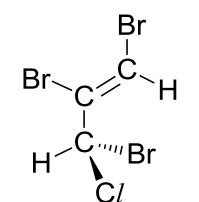
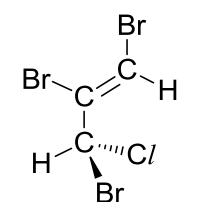
37 Compound **L** has a chiral centre and forms a zwitterion.

Which could be the structure of **L**?

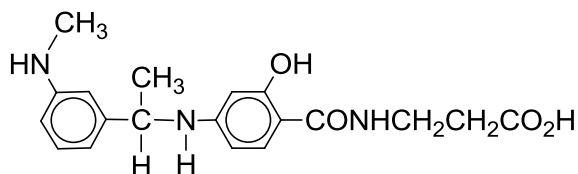


38 In which of the following pairs are the members, **I** and **II**,

- stereoisomers of each other, and
- the overall dipole moment of **I** is larger than that of **II**?

	I	II
1		
2		
3		

39 Which of the following statements regarding compound **T** are correct?



compound **T**

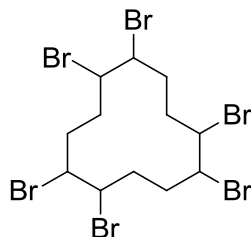
- 1 Compound **T** reacts with excess aqueous bromine to give a product with five bromine atoms.
- 2 1 mol of compound **T** reacts with 3 mol of ethanoyl chloride.
- 3 1 mol of compound **T** reacts with 3 mol of cold dilute hydrochloric acid.

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 The diagram shows a molecule of a compound used as a flame retardant.



Which statements about this structure are correct?

- 1** Each brominated C atom is chiral.
- 2** The molecular formula is $\text{C}_{12}\text{H}_{20}\text{Br}_6$.
- 3** The C–C–C bond angles are all 120° .

Level of difficulty	Percentage	No of questions
Easy	22.5	9
Moderate	55	22
Difficult	22.5	9

MCQ Questions for H2			
Qn	Topic	Remarks	Answer
1	Atomic Structure (p, n, e)	E	D
2	Gases (calculation)	M	A
3	Atoms, Molecules, Stoichiometry (calculation)	M	B
4	Atoms, Molecules, Stoichiometry (equation)	M	A
5	Bonding (χ , bond length) & IE I (acid-base properties)	M	D
6	Bonding (IMF)	M	C
7	Entropy	T	D
8	Enthalpy (ΔH_f , ΔH_c)	M	C
9	E° (electric cells)	T	B
10	IE I (buffer calculation)	M	C
11	Chemical Eqm (K_c calculation)	E	C
12	Kinetics I ($t_{1/2}$ calculation)	E	B
13	Group II (physical properties)	E	C
14	Periodic Table (ionic radius)	M	A
15	Periodic Table (properties of S)	M	D
16	Group VII (Cl_2 + hot OH^- reaction)	E	B
17	Transition Metals (ligand / coordination no.)	T	D
18	Organic (structural isomerism)	M	A
19	Organic (FRS mechanism)	M	C
20	Organic (RCHO, ROH reactions)	M	C
21	Organic (types of mechanism)	M	A
22	Organic (distinguishing test: RCHO, ester, phenol)	M	D
23	Organic (RX: AgNO_3 reaction)	E	A
24	Organic ($\text{C}=\text{C}$, ester, RCO, ROH reactions)	M	B
25	Organic (RX, $\text{C}=\text{C}$, RCO_2H reactions)	T	C
26	Organic (RX, RCO_2H , amine reactions)	T	B
27	Organic ($\text{C}=\text{C}$, ROH, RCO reactions)	T	A
28	Organic (hydrolysis reaction: amide, amine, ester)	M	B
29	Organic (phenol, $\text{C}=\text{C}$, amine reactions)	M	D
30	Organic (amino acid titration curve)	E	C
31	Kinetics II (mechanism, rate equation)	M	B
32	ΔH calculation	M	B
33	E° (fuel cell) + Bonding (bond χ)	T	A
34	IE II (K_{sp} calculation)	T	D
35	Group II (physical/chemical properties)	E	D
36	Transition Metals (reaction)	M	A
37	Organic (amino acid)	E	A
38	Organic (stereoisomers, dipole moment)	M	D
39	Organic (phenol, RCO_2H , amine, amide reactions)	T	B
40	Organic (chiral C, MF, χ)	M	D
Modified/New MCQ Questions for H1			
Qn No	Topic	Remarks	Answer