RAFFLES INSTITUTION
2015 YEAR 6 PRELIMINARY EXAMINATION

HIGHER 2

CHEMISTRY 9647/01

Paper 1 Multiple Choice **28 September 2015**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

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

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number in the spaces provided on the Answer Sheet.

There are **forty** questions on this paper. Answer **all** questions.

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

Section A

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

1 Manganese occurs naturally in many oxides. A sample of a manganese oxide ore consists of a mixture of manganosite (MnO) and braunite (Mn_2O_3), and contains Mn and O in the molar ratio of 0.7:1.

What is the molar ratio of Mn^{2+}:Mn^{3+} in the ore?

A 1:6 **B** 1:5 **C** 1:4 **D** 1:3

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

Uranium, U, is able to form water-soluble salts in which it exists in different oxidation states.

In an experiment, 20.00 cm^3 of 0.100 mol dm^{-3} U^{n+} ions was found to react with 40.00 cm^3 of 0.0200 mol dm^{-3} MnO_4^- ions in acidic medium.

If UO_2^{2+} ions were produced in the reaction, what is the value of n in U^{n+}?

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

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

In which of the following pairs do the two species contain the same number of unpaired electrons?

A C^+, N^- **B** O^-, P^+ **C** Cr^+, Fe^{2+} **D** Mn^{3+}, Co^+

4 The successive ionisation energies, in kJ mol^{-1}, of an element **Z** in period 3 are given below.

770 1542 3208 4331 16091 19805 23780 29287

Which of the following statements about **Z** is correct?

A **Z** is a good conductor of electricity.

B The chloride of **Z** dissolves in water to form its oxide and white fumes.

C The oxide of **Z** reacts with dilute potassium hydroxide.

D **Z** has a simple molecular structure.

5 Which feature is present in the ions CO_3^{2-}, SO_3^{2-}, NO_3^- and HCO_2^-?

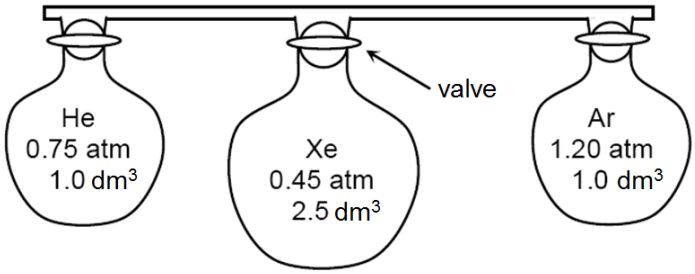
A all bond angles are 120^o

B one dative covalent bond

C three sigma bonds

D eight lone pairs of electrons

6 The following diagram shows the contents of three vessels which are joined together by a connecting tube which has been evacuated.



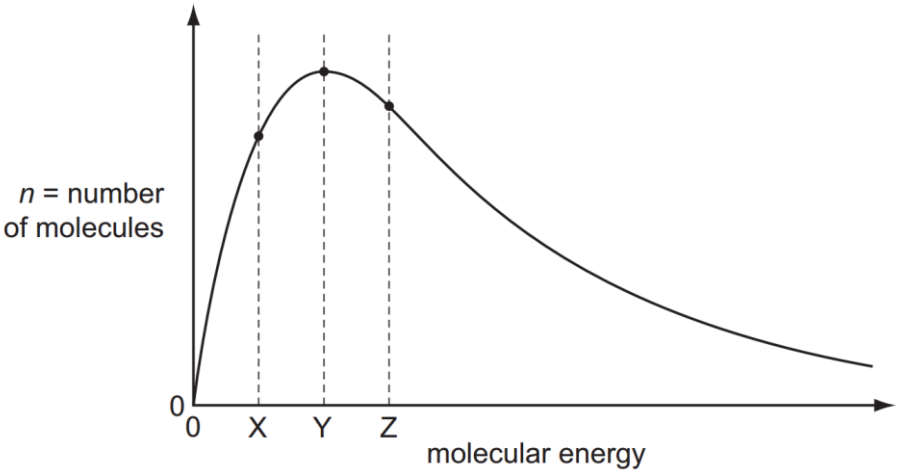
After the valves on the vessels are opened, the final pressure is measured and is found to be 0.675 atm.

If all the vessels and the connecting tube are maintained at 30 ^{o}C, what is the volume of the connecting tube?

A 0.023 dm^3 **B** 0.040 dm^3

C 0.056 dm^3 **D** 0.094 dm^3

7 The Maxwell-Boltzmann distribution for a gas at constant temperature is shown below.



If the temperature of the gas is reduced by 10 ^{o}C, the graph changes shape.

What happens to the values of n for the molecular energies X, Y and Z?

	X	Y	Z
A	higher	higher	higher
B	higher	lower	lower
C	lower	lower	higher
D	lower	lower	lower

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

In a calorimetric experiment, *m* g of propan-1-ol is burnt. *y* % of the energy released is absorbed by 200 g of water, which rises in temperature by 50.5 ^{o}C.

Given that the enthalpy change of combustion of propan-1-ol is –2020 kJ mol^{-1}, which of the following expressions gives the value of *y*?

A $\dfrac{200 \times 4.18 \times 50.5 \times 60.0 \times 100}{2020 \times m}$

B $\dfrac{200 \times 4.18 \times 50.5 \times 60.0 \times 100}{2020 \times 1000 \times m}$

C $\dfrac{m \times 2020 \times 1000}{200 \times 4.18 \times (50.5 + 273) \times 60.0 \times 100}$

D $\dfrac{m \times 4.18 \times 50.5 \times 100}{200 \times 2020 \times 1000 \times 60.0}$

9 When 36.0 g of water boils at 100 ^{o}C, 81.4 kJ of heat is absorbed.

Assuming that ΔH_{vap} and ΔS_{vap} of water do not change with temperature, what is ΔG_{vap} (in kJ mol^{-1}) of water at 50 ^{o}C?

A –2.18 **B** 0 **C** +5.46 **D** +10.91

10 A student carried out an experiment to investigate the decomposition of aqueous H_2O_2 and it was determined to be a first-order reaction. 75% of the H_2O_2 in a solution of concentration 0.10 mol dm^{-3} decomposes in 5.0 minutes.

The student performed another similar experiment using 0.050 mol dm^{-3} aqueous H_2O_2 solution and with a suitable catalyst added. With all other conditions kept the same, 50% of the H_2O_2 in this solution decomposes in *x* minutes.

Which of the following is most likely the value of *x*?

A 2.0 **B** 2.5 **C** 4.5 **D** 5.0

11 If a quantity of $^{2}H_2$ were added to an equilibrium mixture represented by the equation

$$^{1}H_2(g) + I_2(g) \rightleftharpoons 2\ ^{1}HI(g),$$

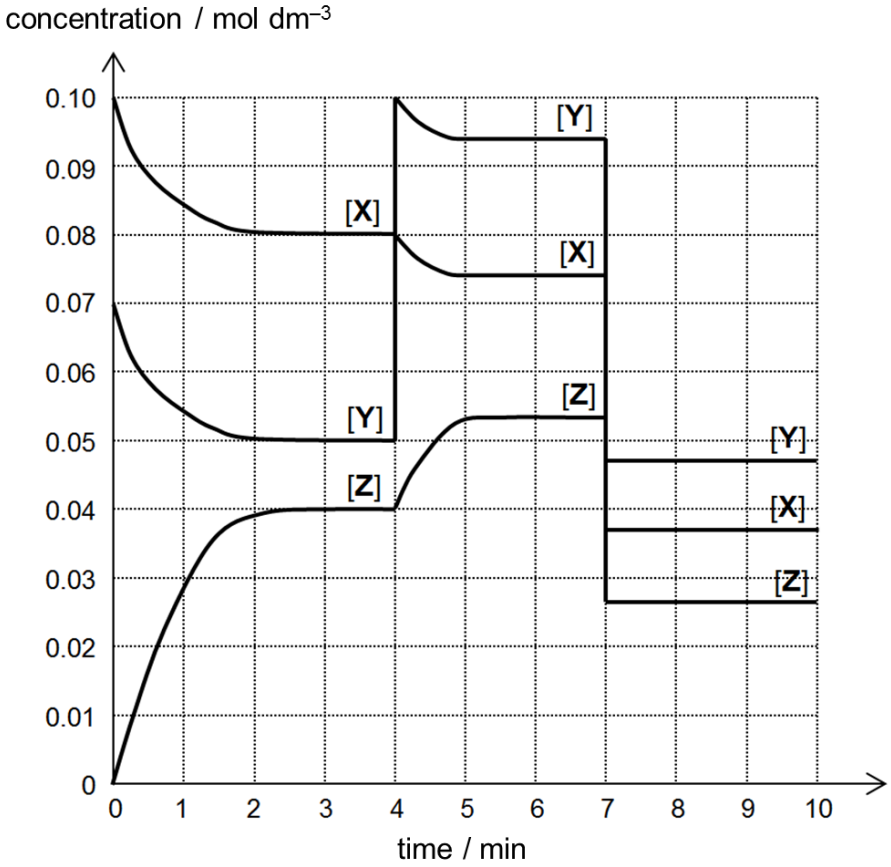
how many different types of hydrogen-containing molecules would be present when equilibrium was re-established?

A 3 **B** 4 **C** 5 **D** 6

12 **X** and **Y** were mixed in a 2 dm^3 vessel and the whole system was allowed to reach equilibrium at temperature T K, as represented by the following equation:

$$\mathbf{X}(g) + \mathbf{Y}(g) \rightleftharpoons 2\mathbf{Z}(g)$$

The concentrations of all gases were measured at one-minute intervals and the operating conditions were altered at the 4th and the 7th minute. The effects are shown in the graph below.



Which of the following can be inferred from the given information?

A The equilibrium constant, K_c, is 4.0 at the 3rd minute.

B 0.10 mol of **Y** was added at constant volume at the 4th minute.

C The volume of the vessel was decreased at the 7th minute.

D The forward reaction rate was faster than the reverse reaction rate at the 8th minute.

13 In an experiment, 20.0 cm^3 of 0.10 mol dm^{-3} hydrochloric acid was added to 25.0 cm^3 of 0.10 mol dm^{-3} aqueous ethylamine (pK_b = 3.25).

What is the pH of the resulting solution?

A 9.80 **B** 10.15 **C** 10.75 **D** 11.10

14 The numerical values of the solubility products of three metal sulfides are tabulated below.

Compound	Numerical value of solubility product
CuS	8.5×10^{-45}
Ag_2S	1.6×10^{-49}
Bi_2S_3	1.1×10^{-73}

Which of the following shows the three metal sulfides arranged in order of increasing molar solubility in water?

A $Bi_2S_3 < Ag_2S < CuS$

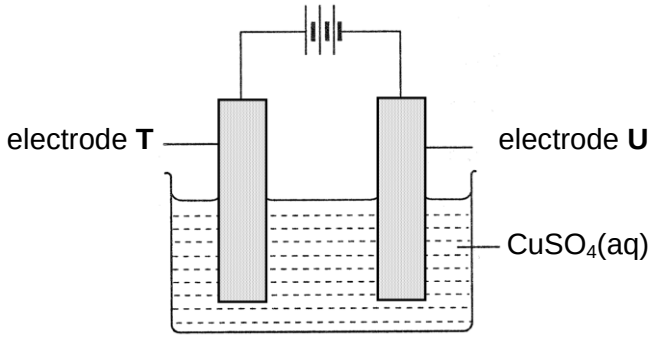
B $CuS < Ag_2S < Bi_2S_3$

C $Ag_2S < Bi_2S_3 < CuS$

D $CuS < Bi_2S_3 < Ag_2S$

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

Impure copper obtained from copper ores can be purified by electrolysis as shown below. The cell potential is adjusted such that copper of the impure copper electrode dissolves and impurities such as silver, iron and zinc can be removed through this process.



Which of the following statements is **not** correct regarding the above electrolytic process?

A Electrode **T** contains impure copper.

B Reduction occurs at electrode **U**.

C Iron and silver impurities fall to the bottom as sludge.

D Zinc impurity goes into the solution as Zn^{2+} ions.

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

Which of the following would change colour when left to stand in the atmosphere?

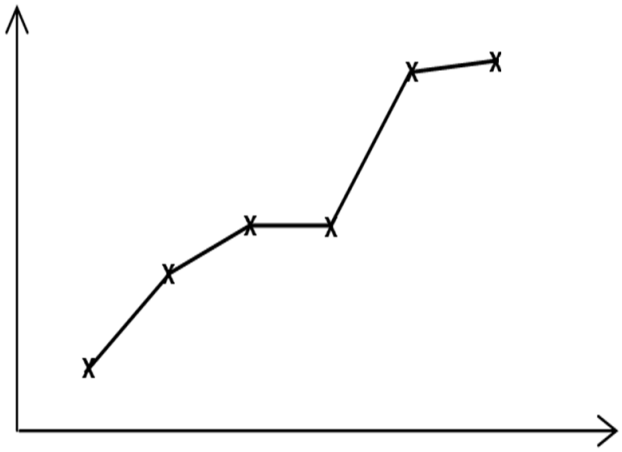
A an acidified solution of cobalt(II) nitrate

B a solution of potassium hexacyanoferrate(III)

C an acidified solution of tin(II) chloride

D an acidified solution of vanadium(II) sulfate

17 The graph below shows the variation in a property of Period 3 (Na to S) elements or compounds.



Which is the property illustrated?

A pOH of the oxide when added to water

B pOH of the chloride when added to water

C boiling point of the chloride

D first ionisation energy of the element

18 Which of the following properties of Group II elements decreases from magnesium to barium?

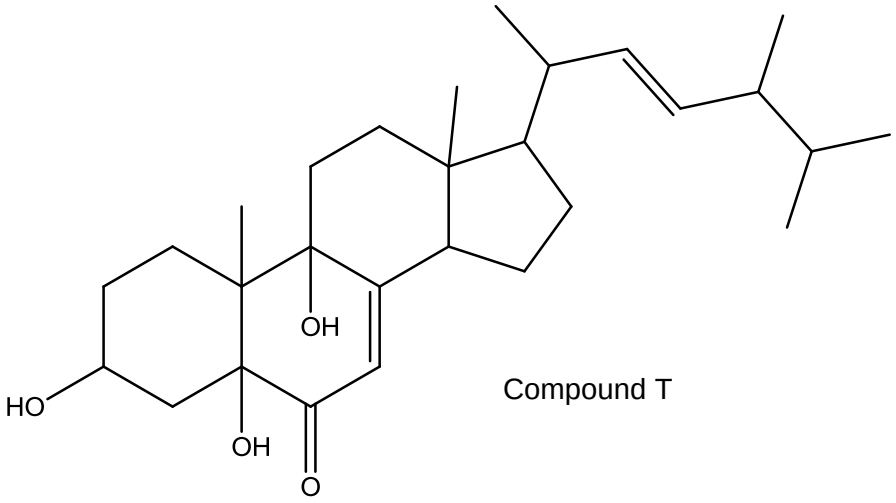
A reactivity with cold water

B magnitude of the standard electrode potential of $M^{2+}(aq)/M(s)$

C electronegativity

D pH of the solution from the reaction of the metal oxides with water

19 Compound T is a cytotoxic steroid isolated from the mushroom *Agaricus blazei*.



Compound T

After compound T is reacted with LiAlH$_4$ in dry ether, how many chiral carbon atoms would be present in the product?

A 9 **B** 10 **C** 11 **D** 12

20 Methane reacts with chlorine in the presence of ultraviolet light. In the mechanism for this reaction,

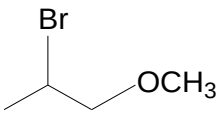
- step *x* has the lowest activation energy, $E_a(x)$ and
- step *y* has an enthalpy change of reaction that is the same as its activation energy, $\Delta H = E_a(y)$.

Which of the following are steps *x* and *y*?

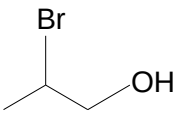
	step *x*	step *y*
A	$Cl\bullet + Cl\bullet \longrightarrow Cl_2$	$Cl\bullet + CH_4 \longrightarrow CH_3\bullet + HCl$
B	$CH_3\bullet + Cl_2 \longrightarrow CH_3Cl + Cl\bullet$	$Cl_2 \longrightarrow Cl\bullet + Cl\bullet$
C	$Cl\bullet + CH_4 \longrightarrow CH_3\bullet + HCl$	$CH_3\bullet + Cl_2 \longrightarrow CH_3Cl + Cl\bullet$
D	$Cl\bullet + Cl\bullet \longrightarrow Cl_2$	$Cl_2 \longrightarrow Cl\bullet + Cl\bullet$

21 Which of the following is the major product when propene is reacted with bromine dissolved in pure methanol?

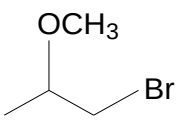
A



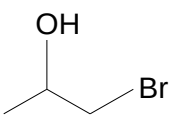
B



C

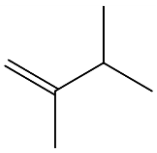
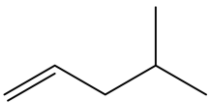
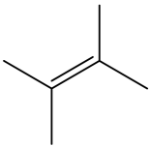
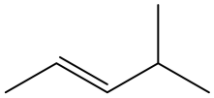


D

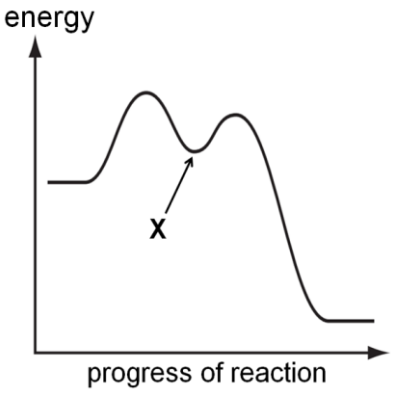


22 An alkene reacts with cold alkaline potassium manganate(VII) followed by hot acidified potassium dichromate(VI) to give a diketone.

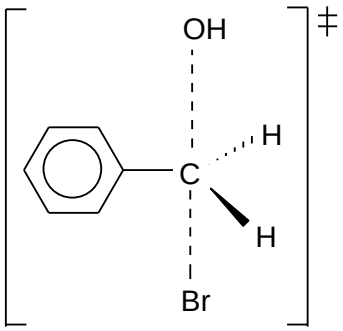
Which of the following is the alkene?

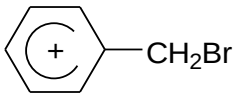
A  **B**  **C**  **D** 

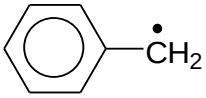
23 The energy profile diagram for the reaction of (bromomethyl)benzene with hot aqueous sodium hydroxide is shown below.

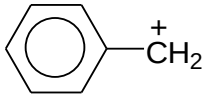


Which of the following represents the species at point **X**?

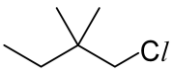
A 

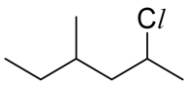
B 

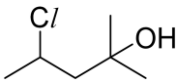
C 

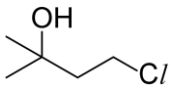
D 

24 Which of the following compounds gives the largest number of isomers (including stereoisomers) when heated with ethanolic potassium hydroxide?

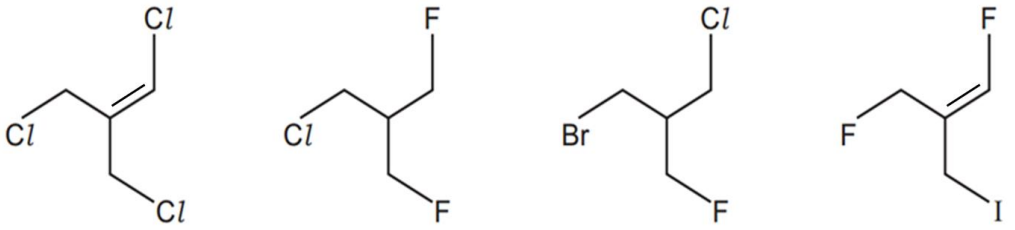
A 

B 

C 

D 

25 In an experiment, the same amount of each of the following trihalogenoalkanes is heated with excess ethanolic silver nitrate in separate test-tubes with constant shaking for the same period of time.



P Q R S

Which of the following statements is correct?

A P produces the largest mass of precipitate among the four compounds.

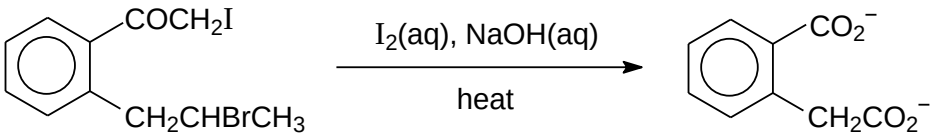
B Q produces a precipitate which is soluble in excess aqueous methylamine.

C R produces three precipitates which are soluble in excess concentrated aqueous ammonia.

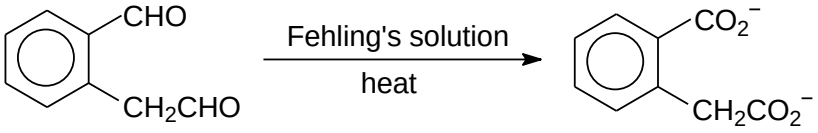
D S produces a precipitate the slowest among the four compounds.

26 Which of the following reactions is most likely to give the product shown?

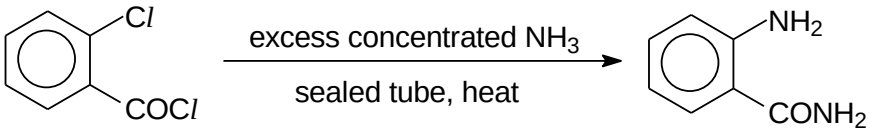
A



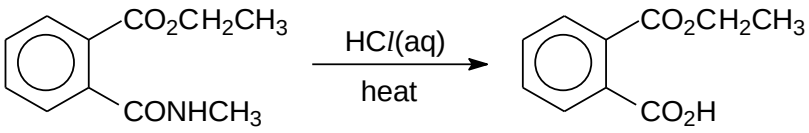
B



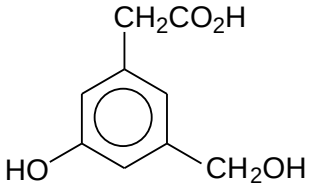
C



D



27 Compound E has the structure shown below.



Compound E

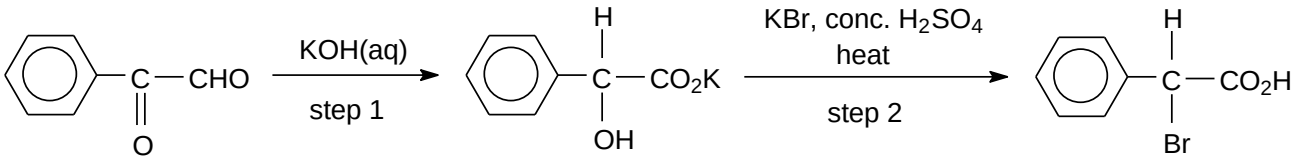
1 mole of E can react separately with

- 1 mole of reagent F,
- 2 moles of reagent G, and
- 3 moles of reagent H.

Which of the following is a possible set of F, G and H?

	F	G	H
A	ethylamine	sodium carbonate	sodium
B	neutral aqueous iron(III) chloride	potassium hydroxide	phosphorus pentachloride
C	sodium hydrogencarbonate	ethanoyl chloride	aqueous chlorine
D	calcium hydroxide	thionyl chloride	calcium

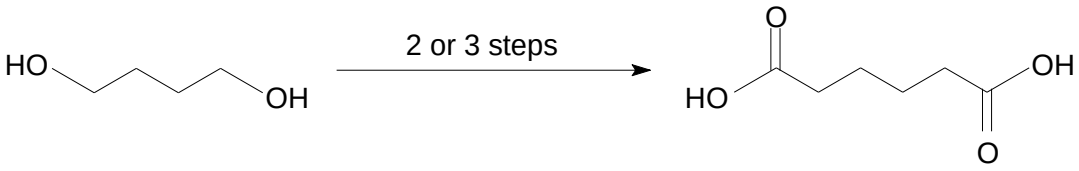
28 A two-step synthetic route is shown below.



Which of the following best describes the reactions which take place in steps 1 and 2?

	step 1	step 2
A	nucleophilic addition	hydrolysis
B	nucleophilic addition	nucleophilic substitution
C	disproportionation	hydrolysis
D	disproportionation	nucleophilic substitution

29 Butan-1,4-diol may be used as the starting material for making adipic acid.



butan-1,4-diol adipic acid

Which of the following sequences of reagents and conditions would be the most suitable?

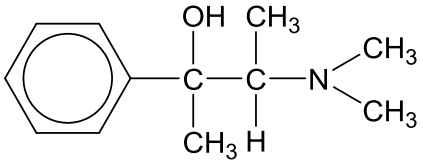
A $\xrightarrow[\text{cold}]{\text{conc. } H_2SO_4}$ $\xrightarrow[\text{heat}]{KMnO_4,\ H_2SO_4}$

B $\xrightarrow[\text{heat}]{\text{ethanolic KCN}}$ $\xrightarrow[\text{heat}]{\text{dilute HC}l}$

C $\xrightarrow[\text{heat with immediate distillation}]{K_2Cr_2O_7,\ H_2SO_4}$ $\xrightarrow[10 - 20\ ^oC]{\text{HCN, KCN}}$ $\xrightarrow[\text{heat}]{\text{dilute HC}l}$

D $\xrightarrow{PBr_3}$ $\xrightarrow[\text{heat}]{\text{ethanolic KCN}}$ $\xrightarrow[\text{heat}]{\text{dilute HC}l}$

30 The structure of a derivative of the alkaloid, ephedrine, is shown below.



Which of the following statements about the given derivative is correct?

A It reacts with CH_3I to form a salt upon heating.

B It reacts with NaOH to form a pungent gas upon warming.

C It reacts with hot alkaline aqueous I_2 to form a yellow precipitate.

D It reacts with aqueous Br_2 at room temperature to form a white precipitate.

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

In 2011 two new elements were added to the Periodic Table. Both elements had been made artificially and were called ununquadium (Uuq) and ununhexium (Uuh).

	Uuq	Uuh
proton number	114	116
nucleon number	289	292

Which statements about these elements are correct?

1 One Uuh atom has one more neutron than one Uuq atom.

2 One Uuh^{+} ion has the same number of electrons as one Uuq^{-} ion.

3 One Uuh atom has the same electronic configuration as one Uuq^{2-} ion.

32 Molecular dimerisation can be described as the process in which two identical molecules combine to give a single product.

Examples of dimers are: $(CH_3CO_2H)_2$, N_2O_4 and Al_2Cl_6

Which of the following descriptions about the above dimers are correct?

1 Hydrogen bonds hold the CH_3CO_2H molecules together in the dimer.

2 All the nitrogen-oxygen bonds in N_2O_4 are of equal length.

3 Al_2Cl_6 is a planar molecule.

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

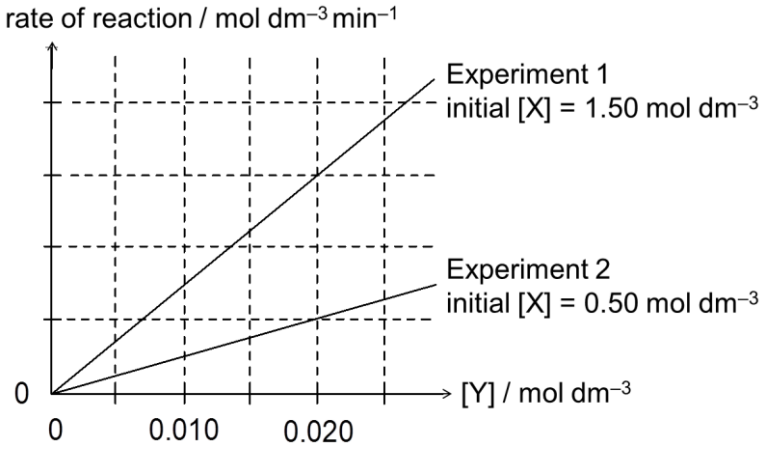
A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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

33 The kinetics of the reaction between X and Y is studied by carrying out two experiments in the presence of excess X.

$$X(aq) + 2Y(aq) \longrightarrow Z(aq)$$

The experimental results obtained are graphically represented below.



Which of the following can be inferred from the given information?

1 The rate constant, k, has units of $mol^{-1}\ dm^3\ min^{-1}$.

2 If the half-life of Y in experiment 1 is t min, the half-life of Y in Experiment 2 would be $3t$ min.

3 If the initial concentration of each reactant in the reaction mixture is halved, the initial rate of the reaction would be halved.

34 The values of the ionic product of water, K_w, at two different temperatures are given below.

Temperature / ^oC	K_w / $mol^2\ dm^{-6}$
30	1.44×10^{-14}
50	5.50×10^{-14}

Which of the following statements are correct?

1 The total concentration of ions in water at 30 ^oC is 1.20×10^{-7} mol dm^{-3}.

2 The concentration of OH^- ions in water at 50 ^oC is higher than that at 30 ^oC.

3 The pH of an aqueous solution of sodium chloride at 50 ^oC is lower than that at 30 ^oC.

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 Consider the following reaction:

$$[Co(NH_3)_6]^{3+}(aq) + 3en(aq) \rightleftharpoons [Co(en)_3]^{3+}(aq) + 6NH_3(aq)$$

where en represents ethylendiammine, $H_2NCH_2CH_2NH_2$.

Which of the following statements are correct about this reaction?

1 ΔH is approximately zero.

2 The co-ordination number of cobalt(III) in $[Co(en)_3]^{3+}$ is 3.

3 The H–N–H bond angle in $[Co(NH_3)_6]^{3+}$ is smaller than that in NH_3.

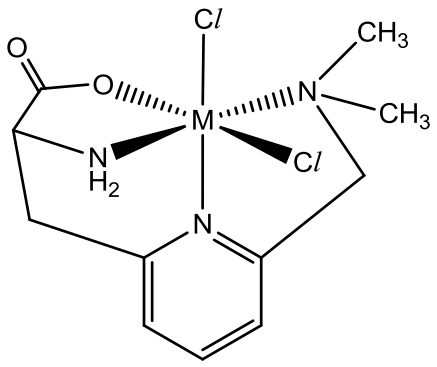
36 What happens when chlorine is bubbled through hot aqueous sodium hydroxide?

1 Chloride ions are formed.

2 Chlorine is reduced by sodium hydroxide.

3 The oxidation number of chlorine changes from 0 to –1 and +7.

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



1 The oxidation number of M is +3.

2 One of the ligands is an amino acid.

3 The complex contains a tetradentate ligand.

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.

38 Which of the following statements about ethanoic acid are correct?

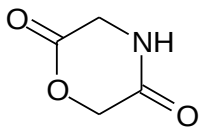
1 It reacts with an equal amount of sodium hydroxide to form a solution with pH more than 7.

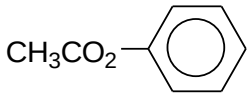
2 It reacts with ethylamine to form *N*-ethylethanamide at room temperature.

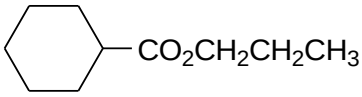
3 It reacts with phenol when heated with concentrated sulfuric acid to form phenyl ethanoate.

39 When compound X is heated under reflux with aqueous sodium hydroxide followed by distillation, the distillate does not contain any organic compounds.

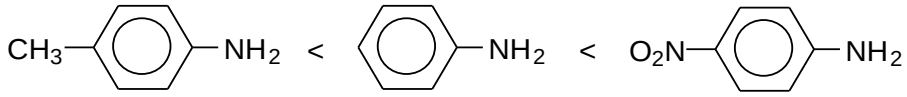
Which of the following could be compound X?

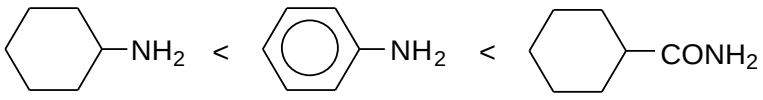
1 

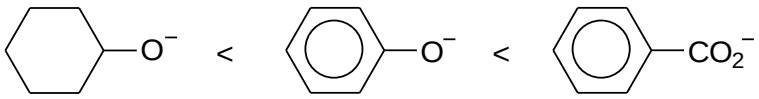
2 

3 

40 Which of the following sequences show the compounds arranged in order of increasing pK_b value?

1 

2 

3 

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