TPJC 2013 H2 Chemistry 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.

How many molecules are present in 1 cm^3 of oxygen gas under room conditions?

A $\frac{1 \times 24000}{6.02 \times 10^{23}}$

B $\frac{1 \times 6.02 \times 10^{23}}{24000}$

C $\frac{6.02 \times 10^{23} \times 24000}{1 \times 1000}$

D $1 \times 6.02 \times 10^{23} \times 32$

2 10 cm^3 of 0.2 mol dm^{-3} K_2XO_4 completely reacts with 40 cm^3 of 0.1 mol dm^{-3} iron(II) sulfate solution.

If Fe^{2+} is oxidised to Fe^{3+} by K_2XO_4, what is the final oxidation state of X?

A +2 **B** +3 **C** +4 **D** +5

3 Which of the following ions would undergo the greatest deflection in an electric field?

A $^{16}O^{2+}$ **B** $^{16}O^{18}O^{+}$ **C** $^{16}O^{18}O^{2+}$ **D** $^{18}O^{2+}$

4 Which of the following consists of species which are all planar?

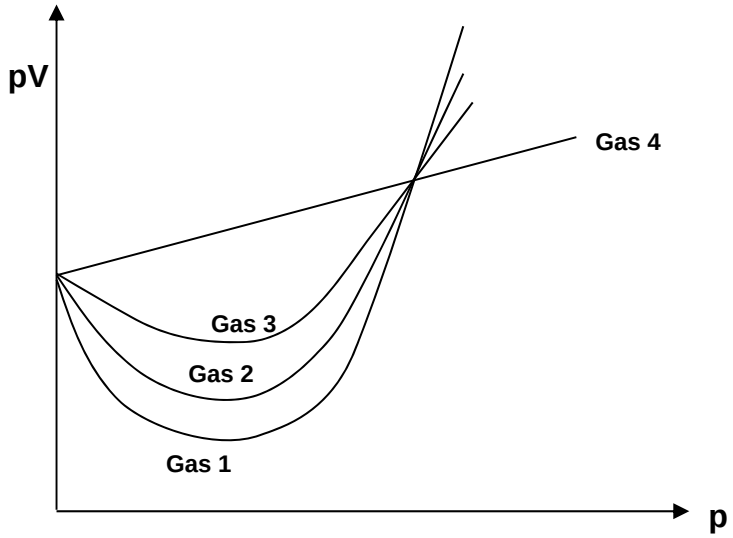
A CO_3^{2-} , SO_3^{2-} and benzene

B Al_2Cl_6 , $SOCl_2$ and methanal

C NO_3^- , XeF_4 and ethanal

D BCl_3 , ICl_4^- and chlorobenzene

5 The value of **pV** is plotted against **p** at the same temperature for four gases, where **p** is the pressure and **V** is the volume of the gas.



Which of the following represent the possible identities of Gases **1** to **4**?

	Gas 1	**Gas 2**	**Gas 3**	**Gas 4**
A	Ne	CH_3F	HF	H_2O
B	Ne	HF	CH_3F	H_2O
C	HF	H_2O	CH_3F	Ne
D	H_2O	HF	CH_3F	Ne

6 The table gives the successive ionisation energies for an element X.

	1st	2nd	3rd	4th	5th	6th
Ionisation energy/ $kJmol^{-1}$	950	1800	2700	4800	6000	12300

What could be the formula of the chloride of X?

A XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

7 The table shows the charge and radius of each of the six ions.

ion	J^+	L^+	M^{2+}	X^-	Y^-	Z^{2-}
radius/nm	0.14	0.18	0.15	0.14	0.18	0.15

The ionic solids JX, LY, and MZ have the same lattice type.

What is the order of their lattice energies starting from the most exothermic first?

A JX, MZ, LY **B** LY, JX, MZ **C** MZ, JX, LY **D** MZ, LY, JX

8 Dinitrogen oxide, N=N=O, burns in ethyne, H–C≡C–H, in the gaseous phase to produce water vapour, carbon dioxide and nitrogen gases as the only products.

$5\ N_2O(g) + C_2H_2(g) \rightarrow H_2O(g) + 2\ CO_2(g) + 5\ N_2(g) \quad \Delta H = -1668\ kJ\ mol^{-1}$

Assuming N=N bond energy in dinitrogen oxide is +418 kJ mol^{-1}, what is the nitrogen-oxygen bond energy in dinitrogen oxide in kJ mol^{-1}?

A 382 **B** 594 **C** 686 **D** 1350

9 Which of the following statements about the spontaneity of the gas-phase reaction shown is true at 25 °C?

$$2\ O{=}N{-}Cl(g) \rightarrow 2\ N{=}O(g) + Cl_2(g)$$

A The reaction cannot be spontaneous.

B The reaction will be spontaneous regardless of the magnitude of ΔH and ΔS.

C The reaction will be spontaneous only if the magnitude of ΔH is large enough to overcome the unfavorable entropy change.

D The reaction will be spontaneous only if the magnitude of ΔS is large enough to overcome the unfavorable enthalpy change.

10 Iodine-131 is a radioactive isotope with a half-life of 8 days. Given that radioactive decay is a first-order reaction, what fraction of the isotope would remain after 80 days?

A $\frac{1}{20}$ **B** $\frac{1}{160}$ **C** $\frac{1}{2^8}$ **D** $\frac{1}{2^{10}}$

11 Which is the correct statement about the following reaction?

$$P(g) + Q(g) \overset{\mathbf{M}(s)}{\rightleftharpoons} R(g) \quad \Delta H < 0$$

A Both the rate constant and equilibrium constant will increase with increasing temperature.

B The solid M will lower the activation energy of both forward and backward reactions.

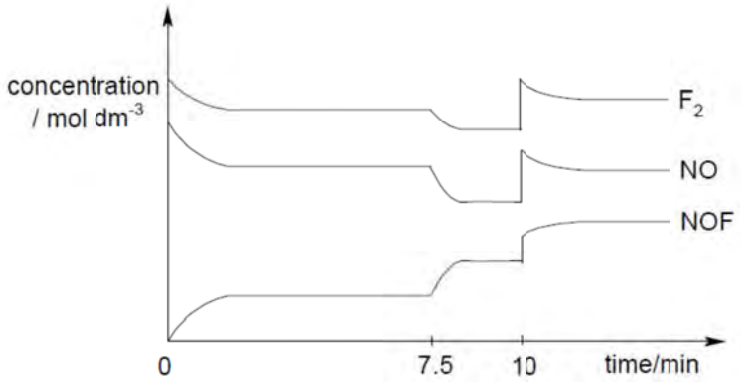
C Increasing temperature will lower the activation energy resulting only in a greater fraction of R molecules with energy greater than activation energy.

D The activation energy of the forward reaction is equal to the activation energy of the backward reaction.

12 The reaction between NO and F_2 was studied by mixing the two gases:

$2NO(g) + F_2(g) \rightleftharpoons 2\,NOF(g) \qquad \Delta H < 0$

At different times during the experiment, various changes were made to the conditions inside the reaction vessel. The changes in concentrations of the three compounds in the equilibrium mixture with time are given by the graph below:



Which of the following statements is correct?

A There was a decrease in volume of the reaction vessel at 10.0 min.

B There was an increase in volume of the reaction vessel at 7.5 min.

C There was an increase in temperature at 10.0 min.

D A catalyst was added at 7.5 min.

13 The value of the ionic product of water, K_w, varies with temperature.

temperature / ^oC	K_w / $mol^2\ dm^{-6}$
0	0.1×10^{-14}
10	0.3×10^{-14}
25	1.0×10^{-14}

What can be deduced from this information?

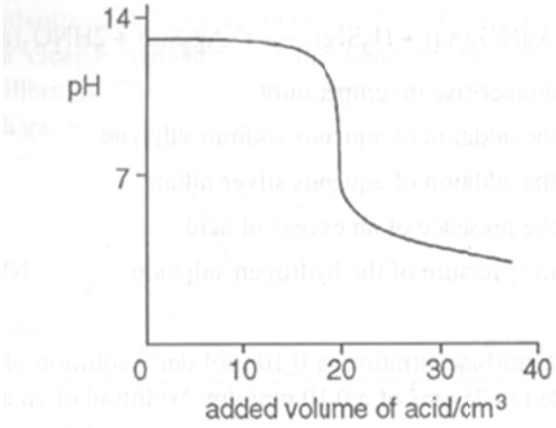
A Molar concentration of H^+ ions decreases with decrease in temperature.

B The ionic product of water decreases by a factor of 10 from 0 °C to 25 °C.

C The association of water molecules by hydrogen bonding increases as temperature increases.

D Water is no longer a neutral liquid at temperatures below 25 °C.

14 The graph shows the change in pH when ethanoic acid is gradually added to 10 cm^3 of 0.10 mol dm^{-3} sodium hydroxide. An indicator is used to determine the end-point for the titration.



Which of the following contains the correct concentration of ethanoic acid and indicator used for the titration?

A 0.05 mol dm^{-3} ethanoic acid, screened methyl orange
B 0.05 mol dm^{-3} ethanoic acid, phenolphthalein
C 0.10 mol dm^{-3} ethanoic acid, screened methyl orange
D 0.10 mol dm^{-3} ethanoic acid, phenolphthalein

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

In many areas, tap water becomes slightly acidic due to dissolved carbon dioxide.

By considering the relevant $E^{\ominus}$ values, which metal will be **least likely** to dissolve in tap water containing carbon dioxide?

A lead **B** zinc **C** iron **D** magnesium

16 When a quantity of electricity was passed through molten vanadium oxide, 5.63 g of vanadium and 2.67 g of oxygen were produced at the electrodes. What is the formula of vanadium oxide?

A VO_3 **B** VO **C** V_2O_3 **D** V_3O_2

17 Phosphorus is an element in the third period, Na to Ar, of the Periodic Table.

What is true for phosphorus and none of the other elements in this period?

A Phosphorus has the highest melting point of the elements in this period.

B Phosphorus is the only element in this period that forms two acidic oxides.

C Phosphorus is the only element in this period with exactly four atoms in its molecule.

D Phosphorus is the only element in this period whose chlorides react with water to form acidic solutions.

18 Which of the following statements about Group II elements from Mg to Ba is incorrect?

A The melting point of the oxides increases down the group.

B The reactivity of the elements with chlorine gas increases down the group.

C The decomposition temperature of the nitrates increases down the group.

D The volume of gases formed per gram of carbonate decomposed decreases down the group.

19 The equations for three reactions are given below:

$$Cl_2\,(g) + H_2S\,(g) \rightarrow 2HCl\,(g) + S\,(s)$$

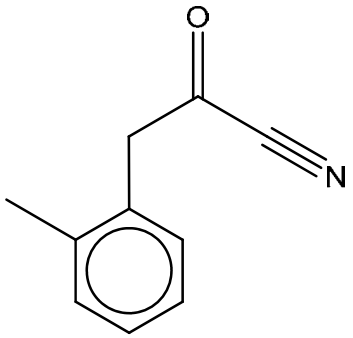
$$SO_2\,(g) + 2H_2S\,(g) \rightarrow 2H_2O\,(l) + 3S\,(s)$$

$$Cl_2\,(g) + 2H_2O\,(l) + SO_2\,(g) \rightarrow 2HCl\,(aq) + H_2SO_4\,(aq)$$

Which is the correct order of strength of the three reacting gases as oxidising agents?

	Strongest ⟶		**Weakest**
A	Chlorine	Sulfur dioxide	Hydrogen sulfide
B	Chlorine	Hydrogen sulfide	Sulfur dioxide
C	Hydrogen sulfide	Sulfur dioxide	Chlorine
D	Sulfur dioxide	Hydrogen sulfide	Chlorine

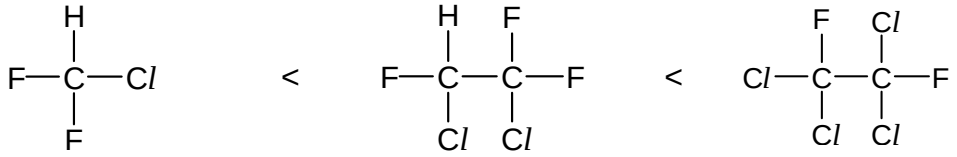
20 What is the number of sp^2 and sp^3 carbon atoms in the structure given below?

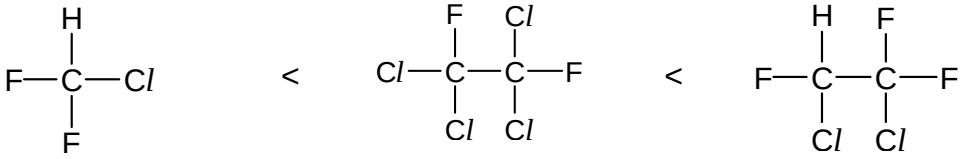


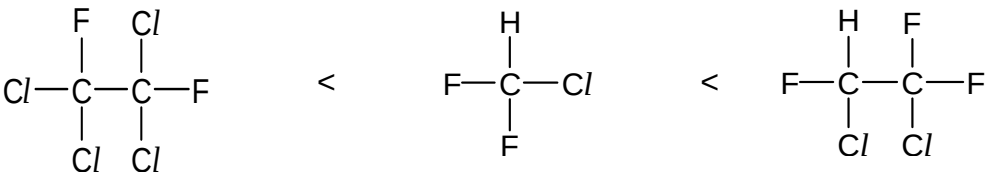
	sp^2	**sp^3**
A	1	2
B	7	2
C	6	1
D	2	1

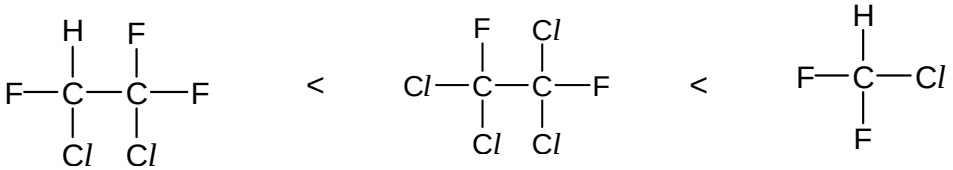
21 Chlorofluorocarbons (CFCs) are commonly used as aerosols, propellants and refrigerants. However in the stratosphere, CFCs can damage the ozone layer through a radical chain reaction.

In which sequence are the following compounds listed in **increasing** order of their ability to destroy ozone?

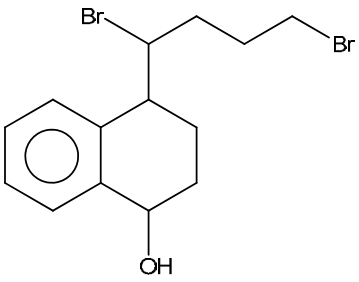
A 

B 

C 

D 

22 What is the total number of possible geometric isomers formed when the following compound is heated with ethanolic KOH?



A 2 **B** 4 **C** 6 **D** 8

23 Hydrobromic acid reacts with ethene to form bromoethane. Which of the following is the best description of the organic intermediate?

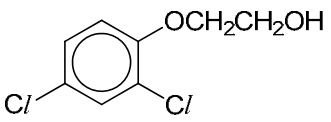
A It contains carbon, hydrogen and bromine.

B It is a free radical.

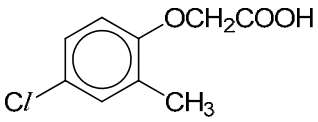
C It is positively charged.

D Its structure is planar.

24 *2,4–D* and *MCPA* are two common selective weed killers.



2,4-D



MCPA

Which one of the following reagents can be used to distinguish between them?

A sodium metal

B phosphorus pentachloride

C hot concentrated potassium manganate(VII)

D hot acidified potassium dichromate

25 Which reagent is suitable for use in separating a mixture of methylbenzene and phenylamine by physical means?

A aqueous sodium hydroxide

B bromine liquid

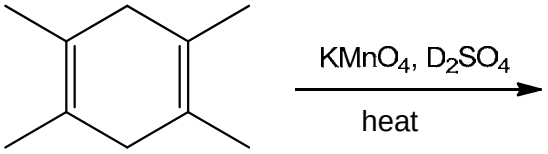
C dilute hydrochloric acid

D ethanoyl chloride

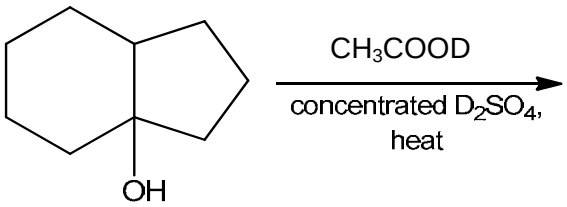
26 Deuterium, D, is an isotope of hydrogen, ${}^{2}_{1}H$.

Which of the following reactions yields a stable organic compound containing deuterium?

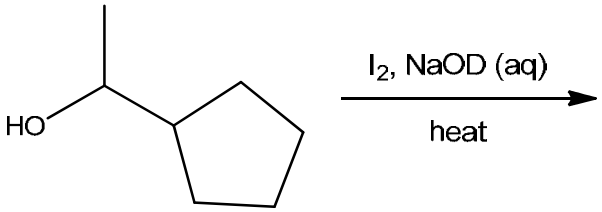
A



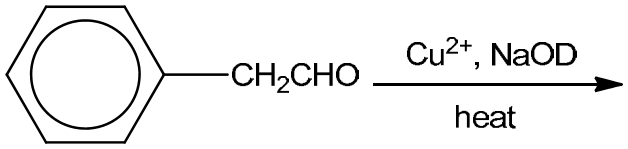
B



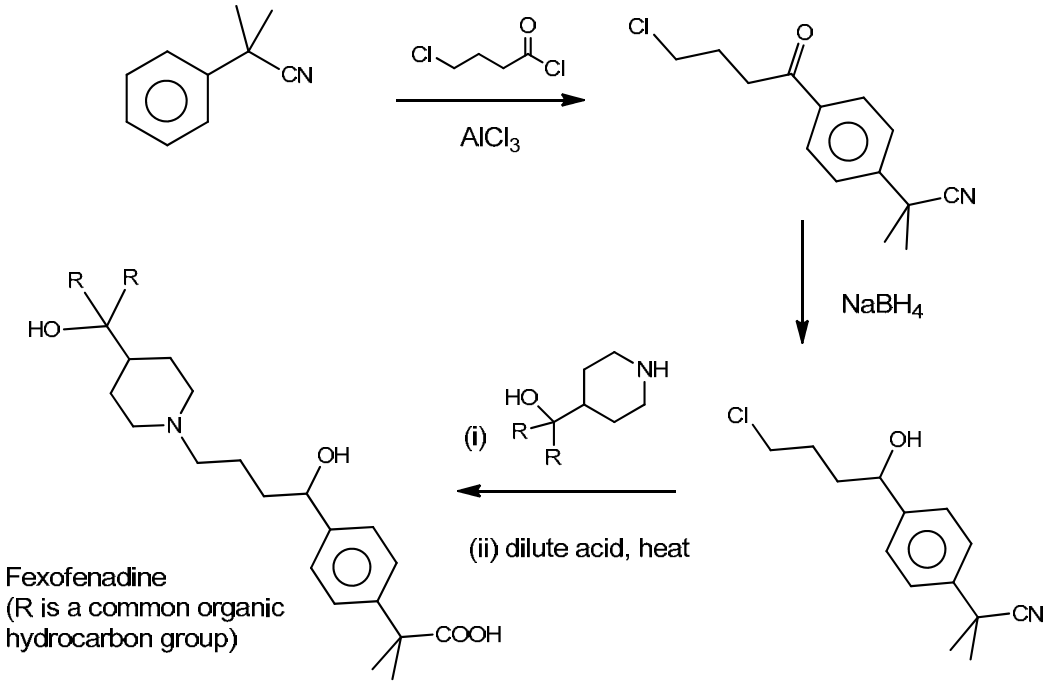
C



D



27 The drug Fexofenadine is used to treat runny nose and itchy eyes without causing drowsiness. A synthesis of Fexofenadine is shown below:



Which of the following reactions does **not** occur in this process?

A reduction **B** nucleophilic addition

C electrophilic substitution **D** hydrolysis

28 Which sequence shows the compounds in order of increasing pK_b values?

A $CH_3CONH_2 < C_6H_5NH_2 < CH_3NH_2 < CH_3NHCH_3$

B $CH_3NH_2 < CH_3NHCH_3 < C_6H_5NH_2 < CH_3CONH_2$

C $CH_3CONH_2 < CH_3NHCH_3 < CH_3NH_2 < C_6H_5NH_2$

D $CH_3NHCH_3 < CH_3NH_2 < C_6H_5NH_2 < CH_3CONH_2$

29 A food chemist wants to create the odour of green apples for a product. An ester with this odour has the formula $C_2H_5CO_2CH(CH_3)_2$. In which of the following will the substances react together to produce this ester?

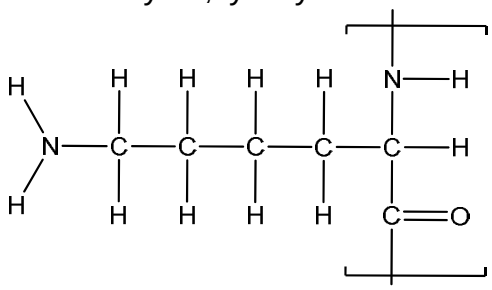
A C_2H_5OH and $(CH_3)_2CHCOOH$

B CH_3COOH and $CH_3CH(OH)CH_2CH_3$

C C_2H_5COOH and $C_2H_5CH_2OH$

D C_2H_5COOH and $(CH_3)_2CHOH$

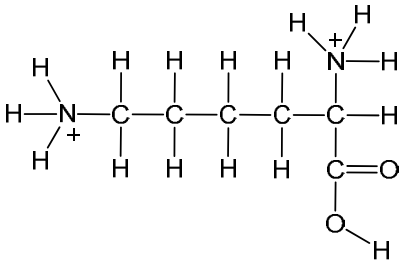
30 The amino acid, lysine has 3 pK_a values of 2.15, 9.16 and 10.67. Lysine residues are present in the enzyme, lysozyme.



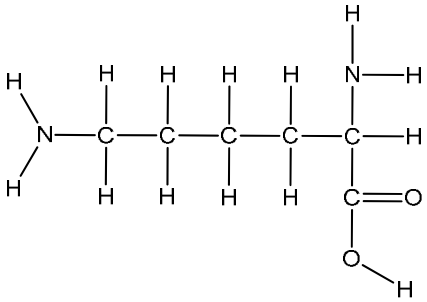
lysine residue

Which of the following structures shows lysine in its most stable state when a sample of lysozyme is hydrolysed and the solution is subsequently adjusted to pH=7?

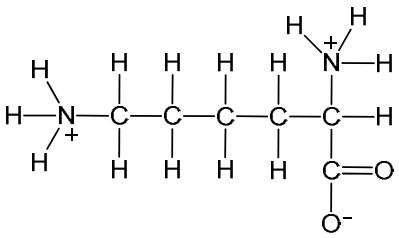
A



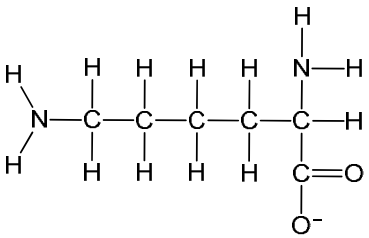
C



B



D



Section B

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

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

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

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

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

31 Which physical properties are due to hydrogen bonding between molecules?

1 Water has a higher boiling point than H_2S.

2 Ice floats on water.

3 The H–O–H bond angle in water is approximately 104^o.

32 In an experiment, 2 moles of SO_2 and 3 moles of O_2 were allowed to react and reach equilibrium in a 1 dm^3 vessel at two different temperatures.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The following results were obtained:

temperature / °C	equilibrium yield of SO_3 / mol
200	1.2
300	0.8

What can you deduce about the reaction from the results?

1 It is an exothermic reaction.

2 The equilibrium constant at 200 °C is 0.94 mol^{-1} dm^3.

3 The backward reaction is favoured at lower temperature.

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

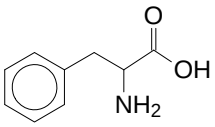
A	B	C	D
1, **2** and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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

33 Which of the following solution's pH will not change significantly when some acid is added?

1 20 cm^3 of 0.100 mol dm^{-3} ethanoic acid mixed with 15 cm^3 of 0.100 mol dm^{-3} aqueous sodium hydroxide

2 20 cm^3 of 0.100 mol dm^{-3} aqueous ammonia mixed with 15 cm^3 of 0.100 mol dm^{-3} ammonium chloride solution

3 20 cm^3 of 0.100 mol dm^{-3} phenylalanine,  solution

34 Which of the following properties **increases** with an increase in the atomic number of the elements in Group II of the Periodic Table?

1 Reducing power of the elements

2 Magnitude of the enthalpy change of hydration of the metal ions

3 Covalent character in the compounds of the elements

35 **X**, **Y** and **Z** are elements in the same 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 correct order of trend for these elements?

1 Proton number: Y < X < Z

2 Atomic radius: Z < X < Y

3 Melting point: X < Z < Y

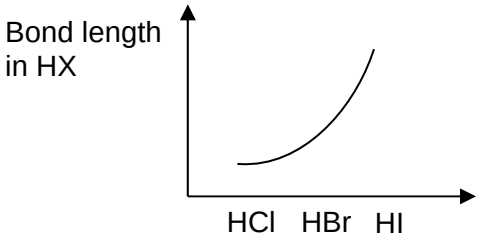
The responses **A** to **D** should be selected on the basis of

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 Which graph(s) show the correct trend for the physical property stated?

1



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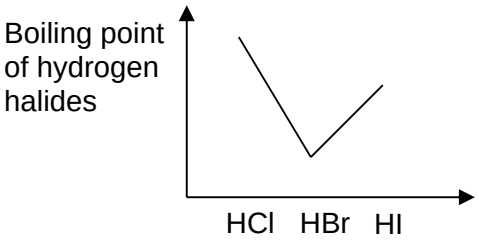

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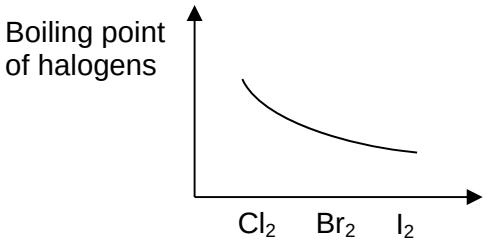


37 Which of the following compounds form a single organic product when reacted with hot acidified potassium manganate (VII)?

1 CH_3-CH=CH_2

2 $(CH_3)_2C=C(CH_3)_2$

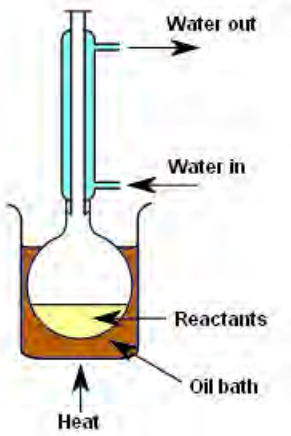
3 HO-CH_2-CHO

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 The diagram shows some laboratory apparatus:



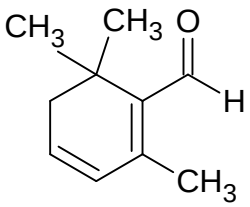
Which preparation(s) could this apparatus be used for?

1 Bromoethane, from ethanol, sodium bromide and concentrated sulfuric acid.

2 Ethanoic acid, from ethanol, sodium dichromate(VI) and sulfuric acid.

3 1,2–dibromoethane, from bromine and ethene.

39 Safranal is a component of the yellow dye in saffron.



Safranal

Which of the following description(s) about safranal are correct?

1 It reacts with KCN in acid at 10 to 20 ^{o}C.

2 It reacts with Fehling's solution.

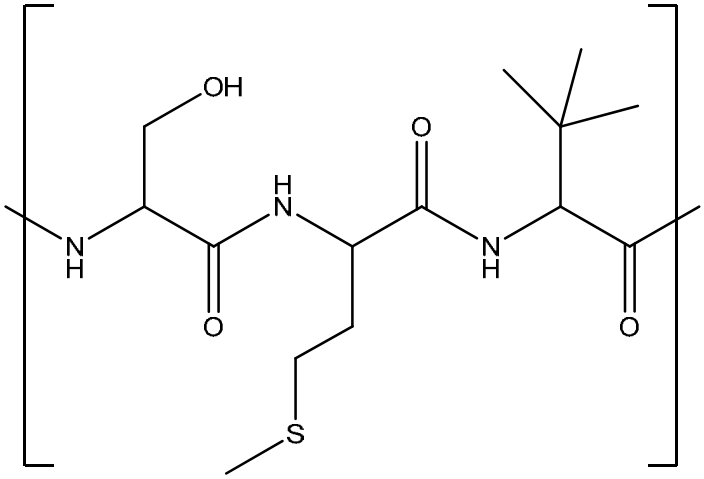
3 It has all atoms lying on the same plane.

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 following shows part of a protein structure.



Which of the following types of interaction is responsible for maintaining the tertiary structure of the protein shown above?

1 van der Waals' forces

2 hydrogen bond

3 disulfide bridge

End of Paper

Answer Key

1	2	3	4	5	6	7	8	9	10
B	C	A	D	D	C	C	C	D	D
11	12	13	14	15	16	17	18	19	20
B	A	A	B	A	C	C	A	A	B
21	22	23	24	25	26	27	28	29	30
A	B	C	D	C	C	B	D	D	B
31	32	33	34	35	36	37	38	39	40
B	B	A	D	B	D	B	B	B	B