RAFFLES INSTITUTION
2016 YEAR 6 PRELIMINARY EXAMINATION

Higher 2

CHEMISTRY 9647/01

Paper 1 Multiple Choice **26 September 2016**

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 in 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 the question booklet.

This document consists of **18** printed pages.

Section A

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

1 Which of the following statements best explains why helium has the highest first ionisation energy among all the elements in the Periodic Table?

A It is unreactive.

B It is the least electronegative element.

C It has only one completely filled principal quantum shell.

D Its valence electron is poorly shielded and is very close to the nucleus.

2 When a beam of protons travelling at the same speed passes through an electric field of constant strength, the protons, $^{1}H^{+}$, are deflected through an angle of $+12^{o}$.

Under identical conditions, which particle would be deflected through an angle of $+8^{o}$?

A $^{2}H^{+}$ **B** $^{3}He^{2+}$ **C** $^{6}Li^{2+}$ **D** $^{12}C^{3+}$

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

Which particle has three unpaired electrons?

A V^{3+} **B** F^{2+} **C** Ni **D** S^{-}

4 $FeSO_4$ reacts with $K_2Cr_2O_7$ in acid solution according to the following equation.

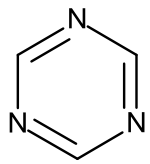
$$14H^{+} + 6Fe^{2+} + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$$

A 20.0 cm^3 sample of $FeSO_4$ solution required 13.10 cm^3 of 0.100 mol dm^{-3} acidified $K_2Cr_2O_7$ for complete reaction.

What was the concentration of the $FeSO_4$ solution?

A 0.0655 **B** 0.153 **C** 0.393 **D** 0.916

5 1,3,5-triazine is an aromatic compound and its structure resembles that of benzene.



1,3,5-triazine

Which statement about 1,3,5-triazine is correct?

A Its empirical formula is CN.

B A molecule of 1,3,5-triazine has six σ bonds.

C The C–N π bond is formed by $2sp^2$–$2sp^2$ overlap.

D All the carbon-nitrogen bonds have equal bond lengths.

6 Which of the following shows the correct shape and bond angle of the molecule given?

	molecule	shape	bond angle
A	OF_2	bent	117^o
B	BH_3	trigonal pyramidal	120^o
C	XeF_4	tetrahedral	109.5^o
D	SF_6	octahedral	90^o

7 At 25 ^{o}C and 101 kPa, a 1.00 g sample of dry air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon and 0.03% carbon dioxide by volume.

What is the average relative molecular mass of the air sample?

A 14.67 **B** 24.52 **C** 28.95 **D** 30.26

8 Which of the following statements about an ideal gas is correct?

A The total volume of the individual molecules is significant when compared to the volume of the container which the gas occupies.

B An ideal gas can liquefy at low temperature and high pressure.

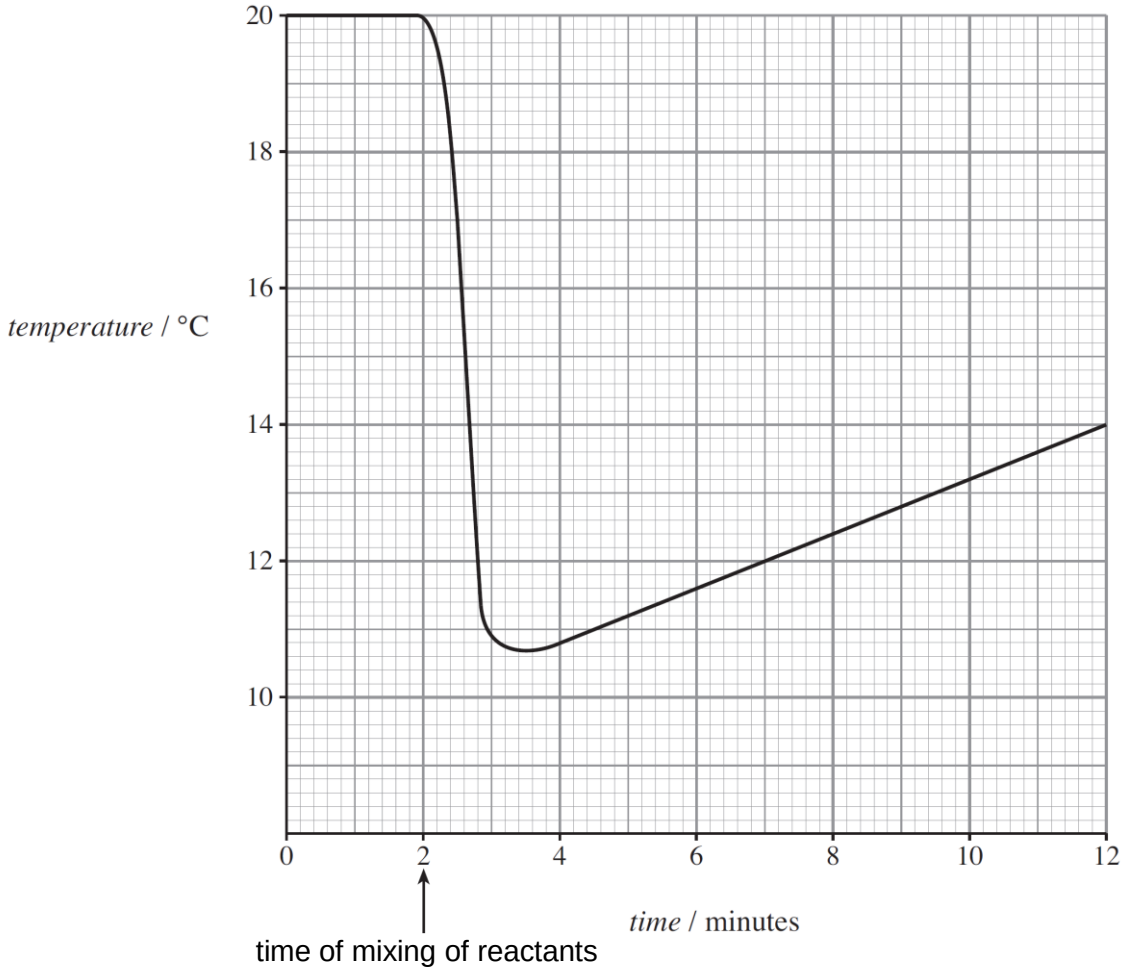
C The gas molecules are in constant, random motion.

D The gas molecules have no mass.

9 Sodium carbonate reacts with ethanoic acid according to the equation below.

$$Na_2CO_3(s) + 2CH_3COOH(aq) \xrightarrow{\Delta H_r} 2CH_3COONa(aq) + H_2O(l) + CO_2(g)$$

In an experiment to determine the enthalpy change of reaction, ΔH_r, 7.5 g of solid sodium carbonate (M_r = 106) was added to 50 cm^3 of excess aqueous ethanoic acid. The temperature of the resultant solution was monitored at various time intervals and the following graph was obtained.



Given that the specific heat capacity of the solution is 4.18 J cm^{-3} K^{-1}, what is the enthalpy change of reaction, ΔH_r?

A +27.5 kJ mol^{-1}

B +29.5 kJ mol^{-1}

C +31.6 kJ mol^{-1}

D +34.0 kJ mol^{-1}

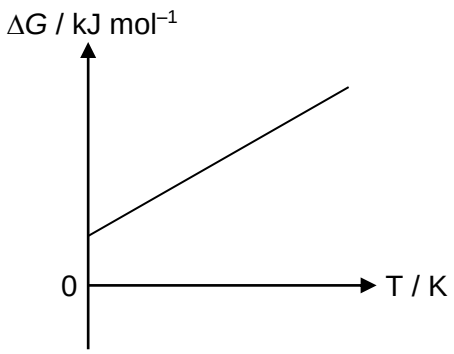
10 The DNA double helix consists of two DNA strands held together by hydrogen bonding.

When heated, the DNA double helix separates into two random-coil single strands. When cooled, the random coils reform the double helix.

DNA double helix ⇌ 2 random coils

Which of the following graphs corresponds to the forward process?

A



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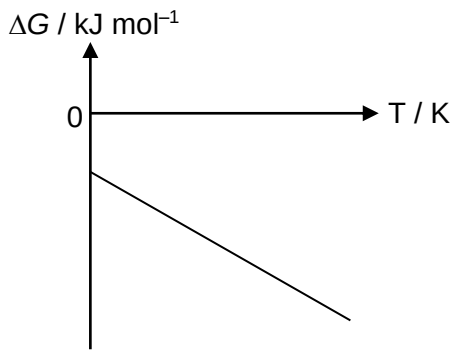

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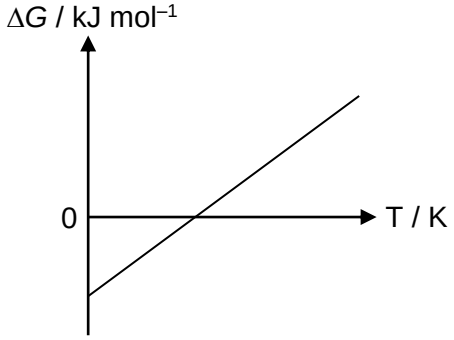

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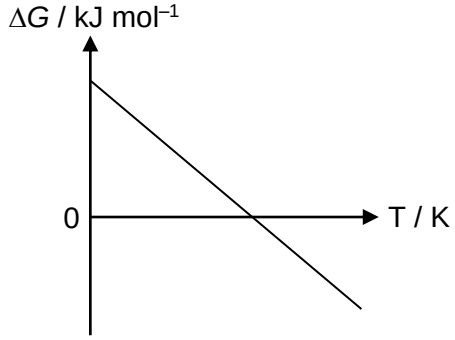


11 *Use of the Data Booklet is relevant to this question.*

1,10-phenanthroline (phen) is an organic compound that is used as a ligand in coordination chemistry. It forms complexes with metal ions such as Fe^{3+} and Fe^{2+}.

The redox equilibrium between $[Fe(phen)_3]^{3+}$ and $[Fe(phen)_3]^{2+}$ is shown below.

$$[Fe(phen)_3]^{3+} + e^- \rightleftharpoons [Fe(phen)_3]^{2+} \qquad E^{\ominus} = x \text{ V}$$

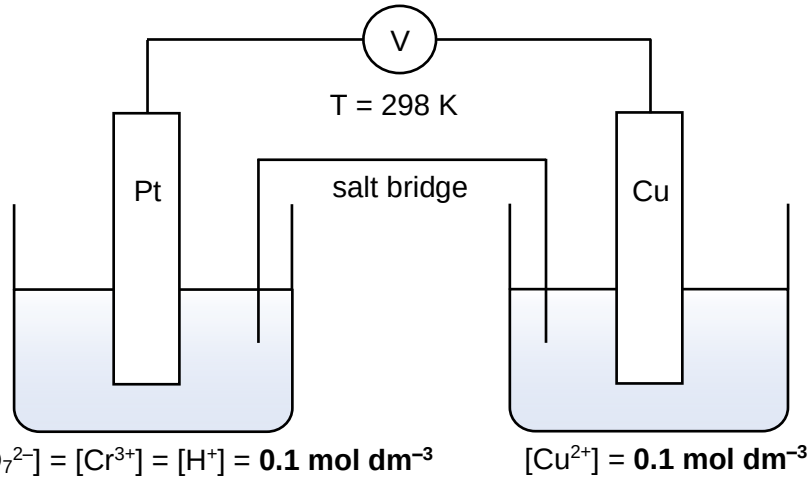
Aqueous chlorine oxidises $[Fe(phen)_3]^{2+}$ to $[Fe(phen)_3]^{3+}$, but both aqueous bromine and iodine do not.

What could be the value of x?

A –0.88 **B** –1.18 **C** +0.88 **D** +1.18

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

An electrochemical cell is set up as shown:



Which statement about the e.m.f. of the above cell is correct?

A The e.m.f. of the cell is +0.99 V.

B Addition of water to the $Cr_2O_7^{2-}/Cr^{3+}$ half-cell decreases the e.m.f. of the cell.

C Addition of $H^+(aq)$ to the Cu^{2+}/Cu half-cell decreases the e.m.f. of the cell.

D Addition of excess $NH_3(aq)$ to the Cu^{2+}/Cu half-cell decreases the e.m.f. of the cell.

13 The two-step mechanism for the reaction

$$2X(g) + Y(g) \rightarrow X_2Y(g)$$

is shown below.

Step 1: $X(g) + Y(g) \rightarrow XY(g)$ (slow)

Step 2: $XY(g) + X(g) \rightarrow X_2Y(g)$ (fast)

Which of the following is the rate equation for the reaction?

A rate = $k[X]^2$

B rate = $k[X][Y]$

C rate = $k[XY][X]$

D rate = $k[X]^2[Y]$

14 Ethanoic acid dissociates in aqueous solution as follows, where α is the degree of dissociation.

$$\underset{1-\alpha}{CH_3CO_2H(aq)} \rightleftharpoons \underset{\alpha}{CH_3CO_2^-(aq)} + \underset{\alpha}{H^+(aq)}$$

Which of the following statements is correct?

A The K_a, in terms of α and initial concentration C, is $\frac{\alpha^2 C}{1-\alpha}$.

B pH decreases with decreasing concentration of ethanoic acid.

C K_a increases with increasing concentration of ethanoic acid.

D α does not change with the concentration of ethanoic acid.

15 The solubility product, K_{sp}, of magnesium hydroxide at 25 ºC is ***X***.

The solubility of magnesium hydroxide at 25 ºC is ***S***.

Which of the following statements is correct at 25 ºC?

A The pH of a saturated solution of magnesium hydroxide is $14 + \lg(2\boldsymbol{X})^{1/3}$.

B The solubility of magnesium hydroxide in a solution of magnesium chloride is larger than ***S***.

C When solid sodium hydroxide is dissolved in a saturated solution of magnesium hydroxide, K_{sp} of magnesium hydroxide becomes smaller than ***X***.

D The K_{sp} of barium hydroxide is smaller than ***X***.

16 Which property of the Period 3 elements, from Na to C*l*, increases consistently across the period?

A enthalpy change of atomisation

B number of unpaired electrons

C electronegativity

D atomic radius

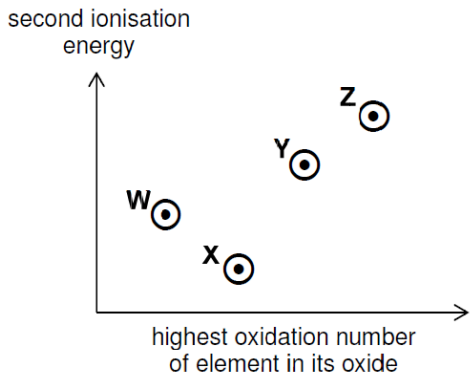
17 *Use of the Data Booklet is relevant to this question.*

W, **X**, **Y** and **Z** are four consecutive elements in the third period of the Periodic Table. The formula of the hydride formed by each element is given in the table below.

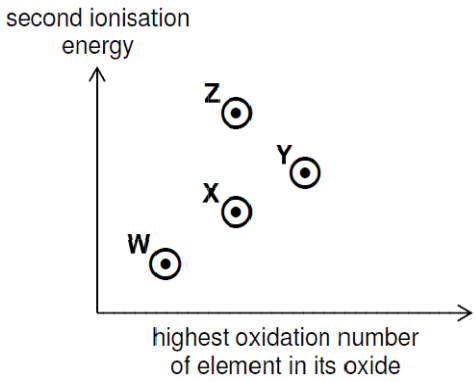
element	**W**	**X**	**Y**	**Z**
formula of hydride	**W**H_2	**X**H_3	**Y**H_4	**Z**H_3

Which of the following shows the correct trends when the second ionisation energies of the elements are plotted against the highest oxidation numbers that the elements exhibit in their oxides?

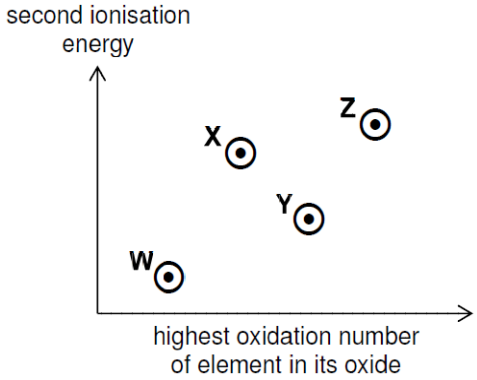
A



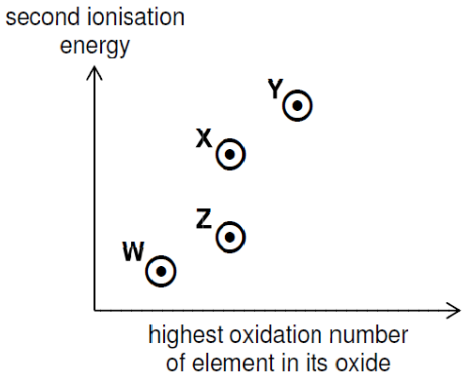
B



C



D



18 An azide ion, N_3^-, is called a pseudohalide because it has some properties which are similar to those of chloride ions.

Which of the following statements is **not** likely to be correct?

A $CH_3CH_2N_3$ reacts with hot, ethanolic KCN to give CH_3CH_2CN.

B N_3^- ions react with a Cu^{2+} ion to give a complex, $[Cu(N_3)_4]^{2-}$.

C HN_3 may be prepared by warming NaN_3 with concentrated H_2SO_4.

D AgN_3 is soluble in water.

19 Which chlorine-containing products are obtained when chlorine is bubbled into hot concentrated NaOH?

A $NaClO_3$ only

B NaClO only

C NaCl and $NaClO_3$

D NaCl and NaClO

20 A Lewis acid is an electron-pair acceptor, while a Lewis base is an electron-pair donor.

1 $C_6H_6 + Br^+ \rightarrow [C_6H_6Br]^+$

2 $CH_3CH_2NH_3^+ + NH_3 \rightarrow CH_3CH_2NH_2 + NH_4^+$

3 $CH_3CH_2^+ + Br^- \rightarrow CH_3CH_2Br$

Which equations represent a Lewis acid-base reaction?

A **3** only

B **1** and **2**

C **2** and **3**

D **1**, **2** and **3**

21 What is the total number of isomers possible for C_3H_4?

A 1 **B** 3 **C** 5 **D** 7

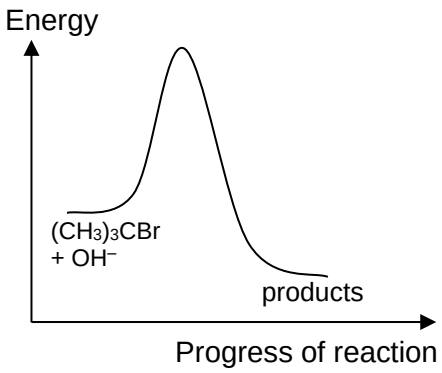
22 The following reaction was found to be exothermic.

$$(CH_3)_3CBr + NaOH \rightarrow (CH_3)_3COH + NaBr$$

The rate equation of the reaction is: rate = $k[(CH_3)_3CBr]$.

Which reaction profile fits the given information?

A



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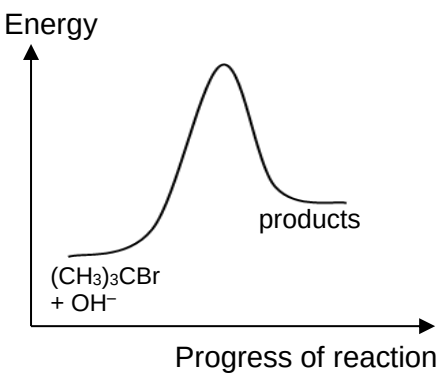

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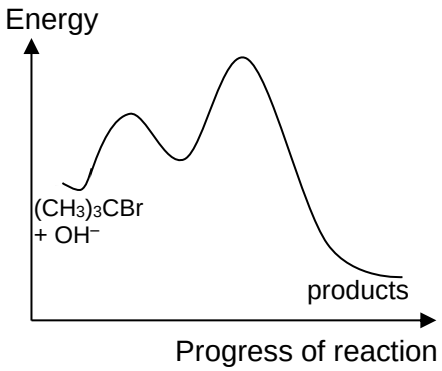

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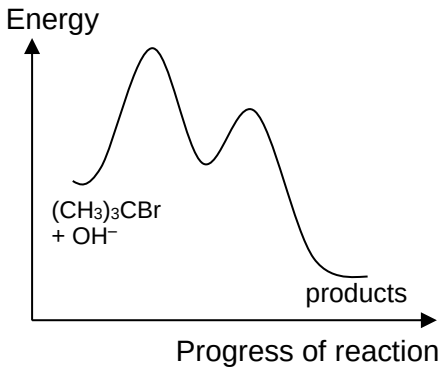


23 One gram of each of the following compounds was heated with NaOH(aq), and then dilute HNO_3(aq) and $AgNO_3$(aq) were added.

CH_3CH_2Cl CH_2=CHBr CH_3COBr C_6H_5I

Which statement is correct?

A The reaction with C_6H_5I gave a pale yellow precipitate.

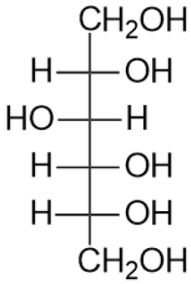
B The reaction with CH_3COBr gave a precipitate that dissolved completely in NH_3(aq).

C The reaction with CH_2=CHBr gave 1.76 g of precipitate.

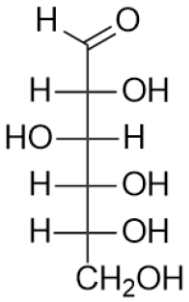
D The reaction with CH_3CH_2Cl gave the largest mass of precipitate.

24 Sorbitol is a sugar alcohol with a sweet taste, and is used as a sugar substitute.

The structures of sorbitol and glucose are given below.



sorbitol



glucose

A sample containing a mixture of sorbitol and glucose reacts completely with 0.2 mol of hydrogen gas in the presence of nickel catalyst.

Another identical sample reacts with excess sodium metal to form 1.4 mol of hydrogen gas at room temperature and pressure.

What is the sorbitol : glucose ratio in the sample?

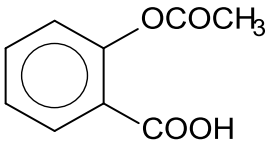
A 3 : 2

B 3 : 1

C 6 : 1

D 7 : 1

25 Aspirin has the following structure.



If 2-hydroxybenzoic acid is used as the starting material for making aspirin, which set of reagents and conditions will give the best yield?

A ethanoyl chloride at room temperature

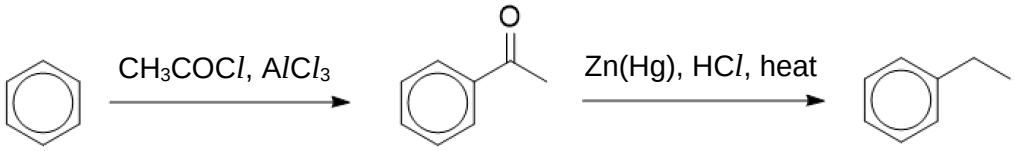
B phosphorus pentachloride at room temperature

C heat with ethanol and a small amount of concentrated sulfuric acid

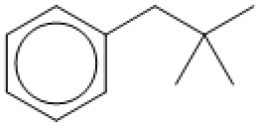
D heat with ethanoic acid and a small amount of concentrated sulfuric acid

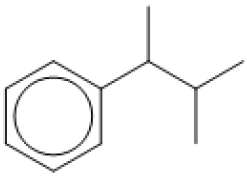
26 Alkylbenzenes can be synthesised from benzene by introducing an acyl group via electrophilic substitution, followed by the reduction of the carbonyl group with zinc amalgam and hydrochloric acid.

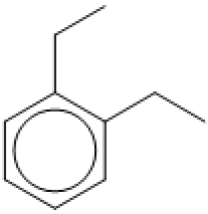
For example, ethylbenzene can be synthesised by the following route:

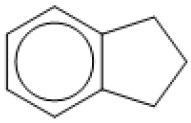


Which compound **cannot** be synthesised by the same method?

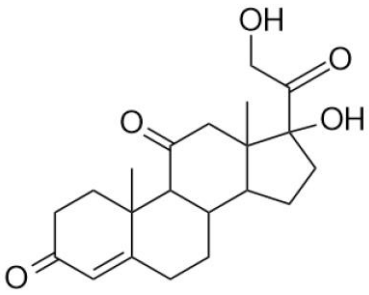
A


B


C


D


27 Cortisone is a hormone released by the adrenal gland in response to stress.



cortisone

When cortisone is reacted with excess lithium aluminium hydride, how many chiral centres will be present in the product molecule?

A 7 **B** 8 **C** 9 **D** 10

28 Consider the following four compounds, which are structural isomers of one another.

1 $CH_2ClCHClCOOH$
2 $CHCl_2CH_2COOH$
3 $CHCl_2COCH_2OH$
4 $ClCH_2OCOCH_2Cl$

Which sequence arranges the compounds in order of decreasing K_a?

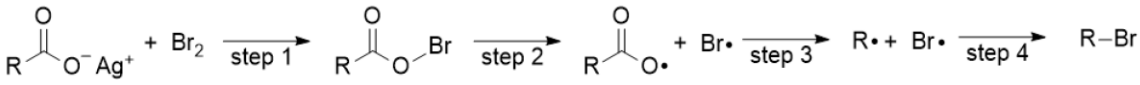
A 1 2 3 4

B 2 1 3 4

C 4 3 1 2

D 4 3 2 1

29 The Hunsdiecker reaction is a reaction in which halogenoalkanes can be produced from silver carboxylate salts, with the use of halogens. A proposed mechanism of the reaction is shown below.



Which statement is **not** correct?

A Step 1 is favoured by the formation of a precipitate.

B Step 2 involves heterolytic fission.

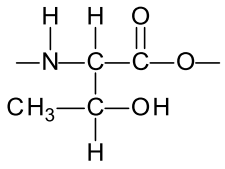
C CO_2 is also a product in step 3.

D Alkane R–R is a possible side-product of the reaction.

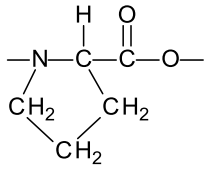
30 In the tertiary structure of a water-soluble globular protein, it was found that the types of amino acid residues present on the outer surface of the protein were different from those present on the inside.

Which of the following amino acid residues is most likely found on the outer surface of such proteins?

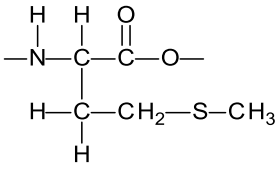
A



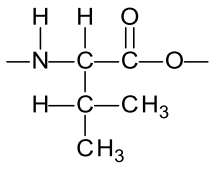
B



C



D



Section B

For each of the following questions, 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

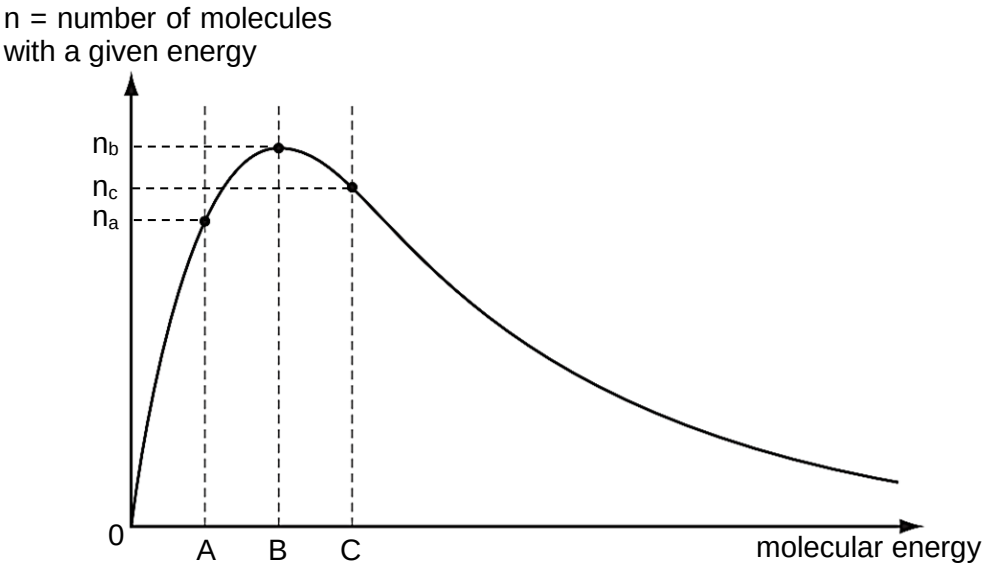
A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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

31 In which pairs does compound **1** have a higher melting point than compound **2**?

	compound 1	**compound 2**
1	$CH_3CO_2NH_4$	$CH_3CH_2NH_2$
2	$SiCl_4$	SiO_2
3	$Ni(CO)_4$	$NiSO_4$

32 The Maxwell-Boltzmann distribution for gas **M** at a given temperature is shown below.



Which statements are correct for the number of molecules with molecular energies A, B and C?

1 n_c decreases when more gas **M** is added at the same temperature.

2 n_a increases when temperature is lowered.

3 Addition of catalyst at the same temperature has no effect on n_a, n_b and n_c.

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

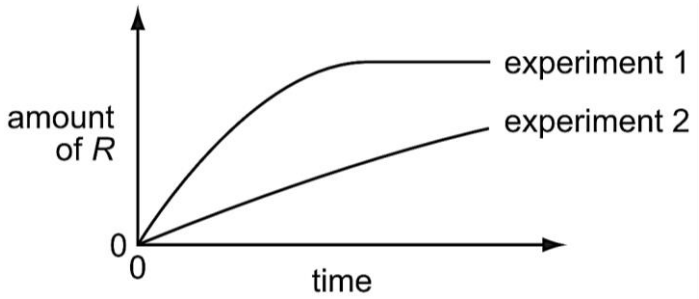
A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

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

33 The stoichiometry of a catalysed reaction is shown by the equation below.

$$P(g) + Q(g) \rightleftharpoons R(g) + S(l)$$

Two experiments were carried out in which the rate of production of *R* was measured. The results are shown in the diagram below.



Which changes in the conditions might explain the results shown?

1 A lower pressure was used in experiment 2.

2 A different catalyst was used in experiment 2.

3 Product *S* was continuously removed from the reaction vessel in experiment 2.

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

Two catalysed reactions and their respective catalysts are shown below.

Reaction	Equation	Catalyst
I	$S_2O_8^{2-} + 2I^- \rightarrow 2SO_4^{2-} + I_2$	Fe^{3+}
II	$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$	Mn^{2+}

Which statements about the reactions and the catalysts are correct?

1 Mn^{2+} is an auto-catalyst in reaction **II**.

2 Fe^{2+} could replace Fe^{3+} as a homogeneous catalyst in reaction **I**.

3 Mn^{2+} could replace Fe^{3+} as a homogeneous catalyst in reaction **I**.

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

Element 117 is one of the most recently discovered elements in the Periodic Table.

In June 2016, the International Union of Pure and Applied Chemistry announced that the discoverers have proposed the name, Tennessine ($_{117}$Ts), for this element.

Which properties are Tennessine most likely to have?

1 Ts is a dark coloured solid at room temperature and pressure.

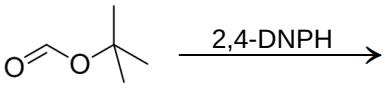
2 The covalent radius of Ts is greater than 0.140 nm.

3 The 6d and 7s orbitals of a Ts atom are completely filled with electrons.

36 Which of the following reactions will form a coloured product?

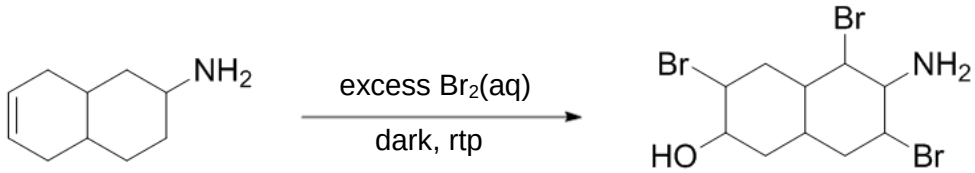
1 $Ca(NO_3)_2(s) \xrightarrow{\text{heat}}$

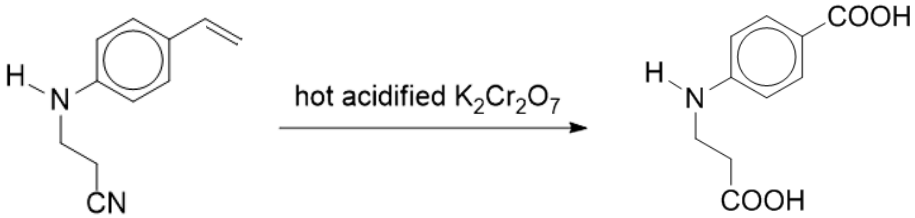
2 $NaI(s) + H_2SO_4(l) \xrightarrow{\text{heat}}$

3 

37 In which reactions is the product shown a possible product?

1 

2 

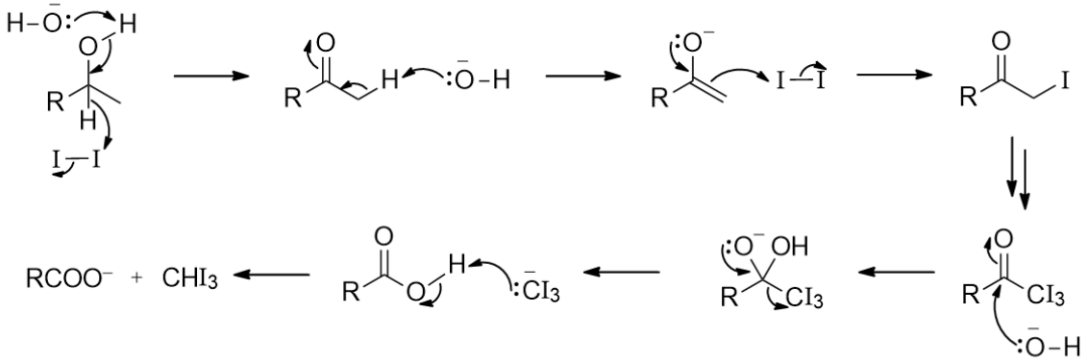
3 

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

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

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

38 The reaction of methyl alcohols with alkaline aqueous iodine can be described by the following scheme:



Which of the following types of reactions are present?

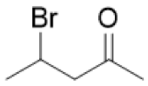
1 oxidation

2 acid-base reaction

3 nucleophilic addition

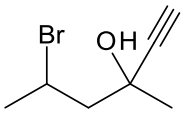
39 Lithium acetylide, $H–C{\equiv}C^- Li^+$, is a useful nucleophilic reagent in organic synthesis.

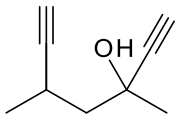
Lithium acetylide is reacted with compound X, followed by the addition of water.

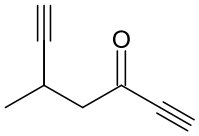


X

Which of the following could be the products of the above reaction?

1 

2 

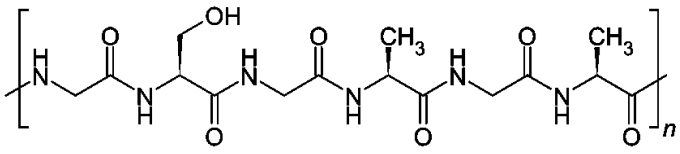
3 

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

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

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

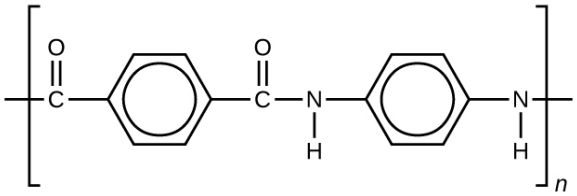
40 Fibroin, a protein present in Spiderman's web, consists of layers of anti-parallel beta-pleated sheets. Its primary structure consists of the amino acid sequence shown below:



Gly Ser Gly Ala Gly Ala

Man-made Kevlar® can be stretched without snapping easily. Spiderman is impressed by the tensile strength of the man-made Kevlar® and intends to upgrade his spider silk so that it will not snap midway through his swings.

The primary structure of Kevlar® is shown below:



Which statements are correct?

1 Both fibroin and Kevlar® have high tensile strength due to their ability to form intermolecular hydrogen bonding between adjacent strands.

2 Kevlar's additional strength is derived from instantaneous dipole – induced dipole interactions between the aromatic rings of adjacent strands.

3 Kevlar® is less water-absorbent than fibroin due to the non-polar aromatic rings, and thus could be used on rainy days.

– END OF PAPER –