CATHOLIC JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS
Higher 2

CHEMISTRY

9647/01

Paper 1 Multiple Choice

Wednesday 29 August 2012

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 and/or shade your name, NRIC / FIN number and HT group on the Multiple Choice Answer Sheet in the spaces provided.

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 Multiple Choice 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.
Calculators may be used.

Section A

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

1 Gallium (A_r = 69.7) occurs naturally as two isotopes, $^{69}_{31}Ga$ and $^{71}_{31}Ga$. What is the percentage of $^{71}_{31}Ga$ atoms in a sample of naturally occurring gallium?

A 33 % **B** 35 % **C** 60 % **D** 65 %

2 The mineral tellurite, TeO_2 (M_r = 160.0) is often used in the manufacture of optic fibres. It was found that 1.01 g of TeO_2 in an ore sample required exactly 60 cm^3 of 0.035 mol dm^{-3} acidified $K_2Cr_2O_7$ for complete reaction. In this reaction, $Cr_2O_7^{2-}$ is converted into Cr^{3+}.

What is the oxidation state of Te in the final product?

A +2 **B** +3 **C** +5 **D** +6

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

What do the ions $^{35}Cl^-$ and $^{40}Ca^{2+}$ have in common?

A Both ions have 18 neutrons.
B Both ions have more protons than neutrons.
C Both ions contain the same number of nucleons.
D Both ions have an outer electronic configuration $3s^2\ 3p^6$.

4 Carbodiimides are often used in organic synthesis as dehydrating agent to activate carboxylic acids towards amide or ester formation. Carbodiimides consist of the general structure, RN=C=NR where R is an alkyl group.

What is the most likely bond angle at each nitrogen atom in carbodiimides?

A 107° **B** 118° **C** 120° **D** 180°

5 Myoglobin, Mb, is an oxygen-carrier protein that exists in the muscle fibres of most mammals. Each Mb molecule will bind to one O_2 molecule, according to the following equation.

$$Mb(aq) + O_2(aq) \rightleftharpoons MbO_2(aq) \qquad K_c = 1\times10^6\ mol^{-1}\ dm^3$$

Given that the concentration of O_2 is 6.5×10^{-6} mol dm^{-3}, what is the percentage of MbO_2 in a Mb-MbO_2 mixture?

A 50.5 % **B** 65.0 % **C** 86.7 % **D** 88.4 %

6 The enthalpy changes involving some oxides of nitrogen are given below:

$N_2(g) + O_2(g) \rightarrow 2NO(g)$ $\Delta H = +180$ kJ mol^{-1}

$2NO_2(g) + \frac{1}{2}O_2(g) \rightarrow N_2O_5(g)$ $\Delta H = -55$ kJ mol^{-1}

$N_2(g) + \frac{5}{2}O_2(g) \rightarrow N_2O_5(g)$ $\Delta H = +11$ kJ mol^{-1}

What is the enthalpy change, in kJ mol^{-1}, of the following reaction?

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

A –235 **B** –125 **C** –114 **D** –57

7 The Thermit Reaction involves mixing iron(III) oxide with aluminium powder in a crucible, with a suitable fuse to start the reaction. The reaction is as follows:

$$Fe_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Fe(l)$$

The fuse is first ignited, where it will burn in oxygen, forming the oxide with a large release of heat required for the Thermit reaction to take place. The commonly used material for the fuse is a clean magnesium strip.

Which of the following does **not** help to explain why a strip of magnesium is suitable to be used as a fuse?

A The large amount of heat energy released on igniting the fuse enables the reactants to overcome the high activation energy involved.
B Magnesium removes the thin layer of oxide on aluminium, thus allowing aluminium to react with the iron(III) oxide.
C The numerical value of the enthalpy change of formation of magnesium oxide is very large.
D The strip increases the surface area for magnesium to react with the oxygen at a faster rate.

8 When a precipitate is formed, $\Delta G_{ppt}^{\ominus}$, in J mol^{-1}, is given by the following expression

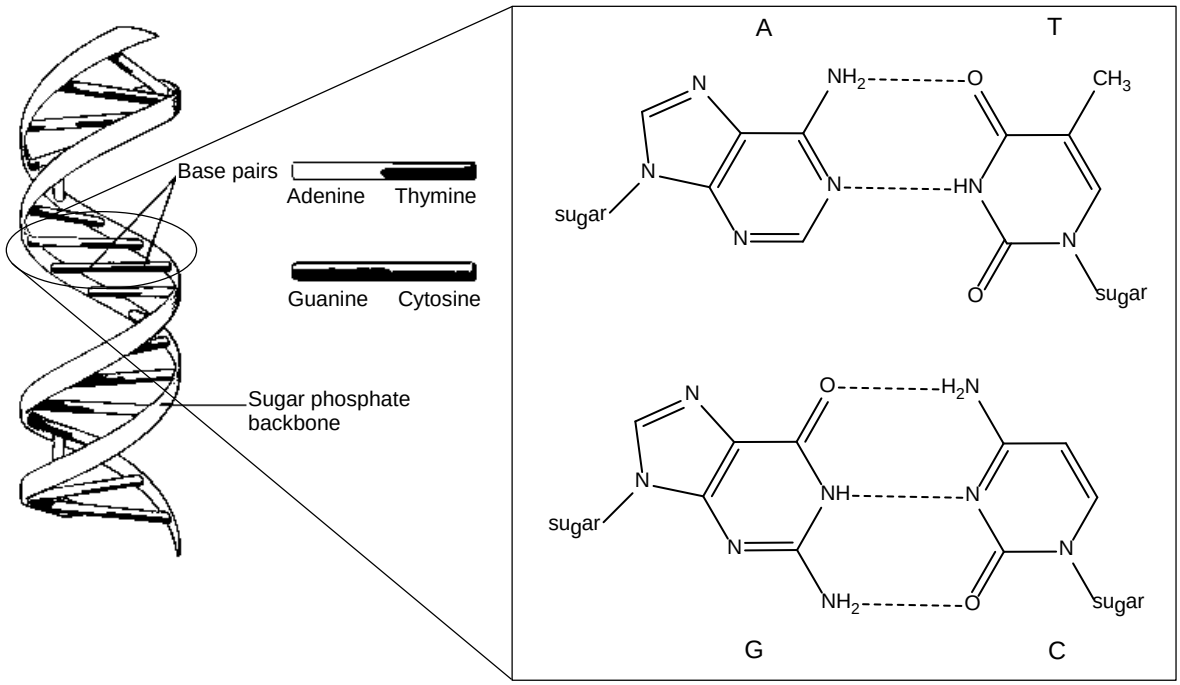
$$\Delta G_{ppt}^{\ominus} = 2.303RT\log K_{sp}$$

Data about AgBr is as follows: $K_{sp}(AgBr) = 5.0\times10^{-13}$ mol^2 dm^{-6}, $\Delta H_{ppt}^{\ominus} = -84.4$ kJ mol^{-1}

What is the $\Delta S_{ppt}^{\ominus}$, in J mol^{-1} K^{-1}, for the formation of AgBr(s) at 298 K?

A – 47.8 **B** – 0.0478 **C** +0.0478 **D** +47.8

9 The secondary structure of DNA is the double helix. The formation of the double helix involves two DNA chains, where one has the bases Adenine (A) and Guanine (G), interacting with the bases Thymine (T) and Cytosine (C) on the other chain as shown below:



The two chains coil together in a helical fashion, and this process is an example of self-assembly.

What are the correct signs of ΔH and ΔS for the formation of the double helix?

	ΔH	ΔS
A	–	–
B	–	+
C	+	–
D	+	+

10 The cell below is set up under standard conditions:

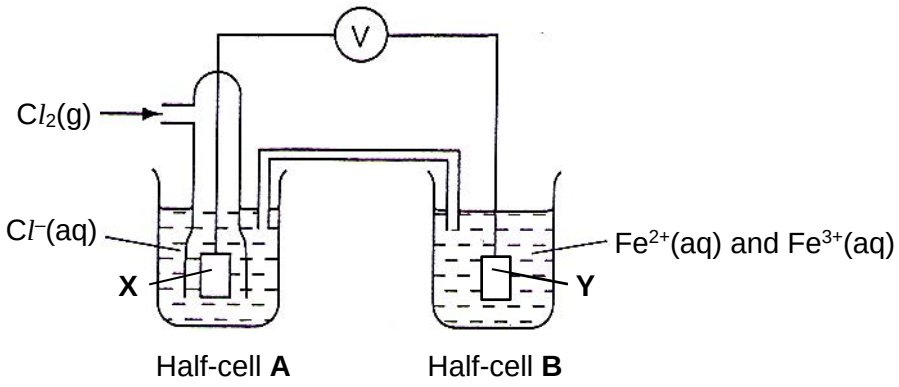
$Pt(s) / Sn^{2+}(aq), Sn^{4+}(aq) // HNO_2(aq), H^+(aq) / NO(g) / Pt(s)$ $\quad E_{cell}^{\ominus} = +0.84$ V

Which of the following changes will cause the cell e.m.f. to be less than +0.84 V immediately after the cell is being set up?

A adding NaOH(aq) to the $HNO_2(aq)$ / NO(g) half-cell
B adjusting the partial pressure of NO(g) to be 0.5 atm
C adding water to the $Sn^{4+}(aq)/Sn^{2+}(aq)$ half-cell
D adding $SnCl_2$ to the $Sn^{4+}(aq)/Sn^{2+}(aq)$ half-cell

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

The cell shown in the diagram is set up under standard conditions where **X** and **Y** are platinum electrodes.



Which of the following statements is correct?

A Changing **X** to Fe in half-cell **A** will not affect $E_{cell}^{\ominus}$.
B The voltmeter will show a reading of about 1.80 V.
C The electrons will flow from **Y** to **X** through the voltmeter.
D **Y** will be the positive electrode.

12 Ethyl ethanoate is a common ester formed during production of wines. It gives the aroma found in younger wines and contributes towards the "fruitiness" perception in wine. The formation of ester in wine can be illustrated by the following equation.

$CH_3CH_2OH + CH_3CO_2H \rightleftharpoons CH_3CO_2CH_2CH_3 + H_2O$ $\quad K_c = 4.0,\ \Delta H = -20$ kJ mol^{-1}

Which of the following statement is correct about the above equilibrium?

A As water is removed from wine, $[CH_3CO_2CH_2CH_3]$ and K_c increases.
B As temperature of the wine decreases, $[CH_3CO_2CH_2CH_3]$ and K_c increases.
C As water is added to the wine, $[CH_3CO_2CH_2CH_3]$ increases.
D As CH_3CO_2H is removed from the wine, $[CH_3CO_2CH_2CH_3]$ increases.

[Turn over

13 HA is a weak acid and can have different degree of acidity in aqueous solution and in liquid ammonia. The respective equations that represent their dissociations are as follow.

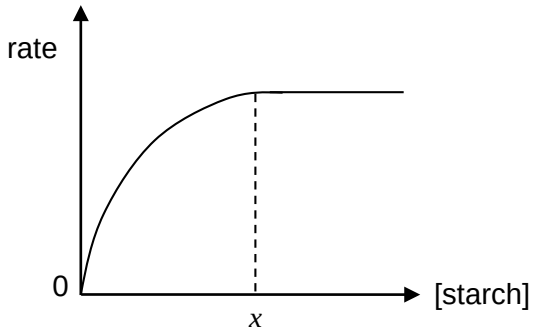
$$HA + H_2O \rightleftharpoons A^- + H_3O^+$$
$$HA + NH_3 \rightleftharpoons A^- + NH_4^+$$

Which of the following statement is correct?

A Ammonia is more polar than water, resulting in greater dissociation of HA.
B Degree of dissociation of HA is identical in aqueous solution and liquid ammonia.
C pK_a of NH_3 is larger than that of H_2O, hence HA is a stronger acid in liquid ammonia.
D K_b of NH_3 is larger than that of H_2O, hence HA is a stronger acid in liquid ammonia.

14 Amylase is the first enzyme discovered and isolated. It acts as a catalyst in the hydrolysis of starch.

In a single experiment, the rate of hydrolysis of starch was monitored as the reaction proceeded and the following graph was obtained.



Which of the following statement about the reaction is **not** correct?

A When [starch] is smaller than x, the rate changes as [starch] changes.
B When [starch] is larger than x, the active sites of amylase are fully occupied.
C The order of reaction with respect to starch is constant at all concentrations.
D Throughout the experiment, [amylase] remains constant as it is not used up.

15 Oxides of two unknown elements of the third period have the following properties. Both can be dissolved in an alkali and when added separately to water, the resultant pH was approximately 7 and 3 respectively.

Which of the following pairs could have been the oxides?

A Al_2O_3 and P_4O_{10}
B Al_2O_3 and Na_2O
C Na_2O and SiO_2
D SO_3 and P_4O_{10}

16 Two students were tasked to prepare pure hydrogen iodide from solid potassium iodide. The first student used concentrated H_2SO_4 as the reagent, while the second student used concentrated H_3PO_4 instead. Only one student was successful in preparing pure hydrogen iodide.

Which of the following is the most likely explanation and/or observation?

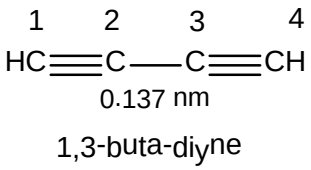
A First student was unsuccessful, as hydrogen iodide formed further react to give purple fumes of iodine and hydrogen sulfide which contaminates the product.
B First student was successful, as hydrogen iodide can be quickly isolated due to its low boiling point.
C Second student was unsuccessful, as H_3PO_4 is a weaker acid than H_2SO_4, thus hydrogen iodide cannot be formed.
D Second student was successful, as H_3PO_4 is a weaker reducing agent than H_2SO_4.

17 Transition metals have many interesting properties.

Which statement correctly describes a property **unique** to transition metals?

A They form metal ions which form dative covalent bonds with ligands.
B They form compounds which can exhibit colours due to partially filled d-orbitals.
C They are the only metals which have high melting and boiling points.
D They are the only metals which have variable oxidation states.

18 The bond lengths in buta-1,3-diyne differs from those which might be expected.
The carbon-carbon bond length in ethane (C_2H_6) is 0.154 nm and in ethyne (C_2H_2) is 0.120 nm. The single C2-C3 bond in buta-1,3-diyne, however is shorter than the single bond in ethane: it is 0.137 nm.



1,3-buta-diyne

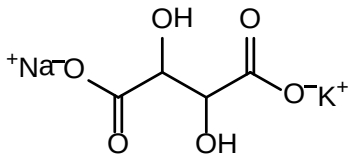
What helps to explain this C2-C3 bond length in buta-1,3-diyne?

A It is an sp-sp overlap.
B It is an sp^2-sp overlap.
C The sp^3-sp^3 overlap is pulled shorter by a p-p (π-bond) overlap.
D The electrons in the filled p-orbitals on C2 and C3 repel each other.

19 Which of the following gases is **not** removed by catalytic converters from the exhaust fumes of cars?

A CO **B** H_2O **C** NO_2 **D** CH_4

20 Potassium sodium tartrate, also known as Rochelle salt, is used medicinally as a laxative and has the following structure.



Which of the following could be part of the reaction sequence to synthesise Rochelle salt?

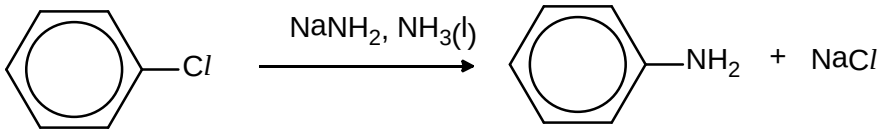
A $(CHO)_2$ —[$HCN_{(aq)}$ + NaCN; 10 °C - 20 °C]→ intermediate —[$KOH_{(aq)}$ + $NaOH_{(aq)}$; reflux]→ Rochelle salt

B CH_2BrCH_2Br —[$KCN_{(alc)}$; reflux]→ intermediate —[$KOH_{(aq)}$ + $NaOH_{(aq)}$; reflux]→ Rochelle salt

C CH_3COCH_3 —[$HCN_{(aq)}$, $NaOH_{(aq)}$; 10 °C- 20 °C]→ intermediate —[$KMnO_4$, $OH^-_{(aq)}$; reflux]→ Rochelle salt

D $CH_3(CH_2)_3Cl$ —[$KOH_{(aq)}$; reflux]→ intermediate —[$KMnO_4$, $OH^-_{(aq)}$; reflux]→ Rochelle salt

21 Phenylamine can be synthesised via a one-step reaction as shown below.

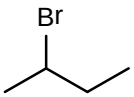


What type of reaction has occurred?

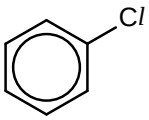
A Electrophilic substitution
B Electrophilic addition
C Nucleophilic substitution
D Nucleophilic addition

22 A halogen derivative, **X**, was first warmed with aqueous sodium hydroxide, followed by adding excess of dilute nitric acid and aqueous silver nitrate. A precipitate was produced. Dilute aqueous ammonia was then added and a colourless solution is obtained. Which of the following could be the identity of compound **X**?

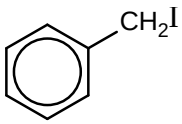
A



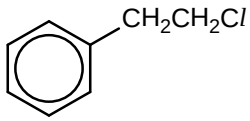
B



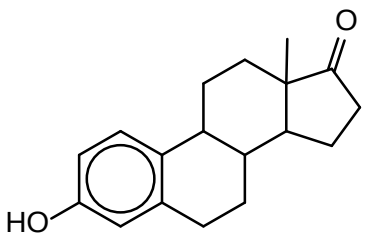
C



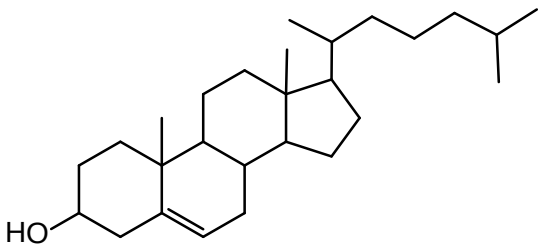
D



23 Estrone, one of several natural estrogens, can be converted from cholesterol via steriodogenesis. The structures of both compounds are shown below.



estrone



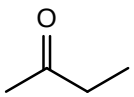
cholesterol

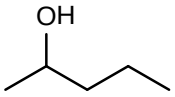
Which of the following **cannot** be used to distinguish estrone from cholesterol?

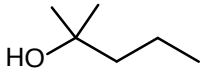
A 2,4-dinitrophenylhydrazine, warm
B neutral $FeCl_3$(aq)
C PCl_5
D Br_2(aq)

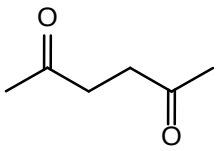
24 Compound **R** was warmed with aqueous iodine in the presence of aqueous sodium hydroxide. After filtration and removal of unreacted iodine, the resultant organic product was heated with ethanol in the presence of concentrated sulfuric acid to give ethyl butanoate.

Which of the following could compound **R** be?

A 

B 

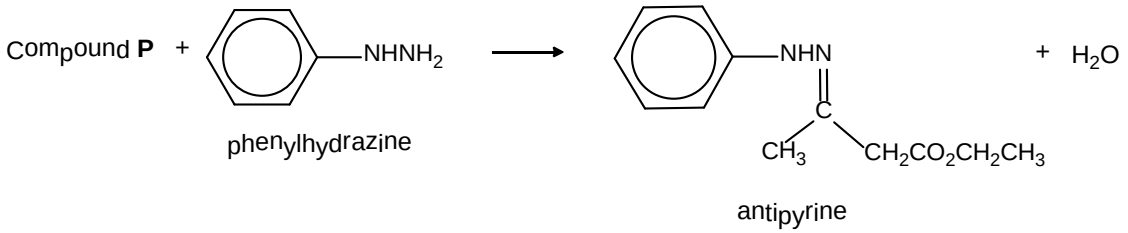
C 

D 

25 Which procedure gives the highest yield of ethyl benzoate?

A refluxing CH_3CO_2H with $SOCl_2$, then adding phenol
B refluxing CH_3CH_2OH with concentrated HCl, then adding $C_6H_5CO_2H$
C refluxing $C_6H_5CO_2H$ with $SOCl_2$, then adding CH_3CH_2OH
D refluxing CH_3CH_2OH with concentrated H_2SO_4, then adding $C_6H_5CO_2H$

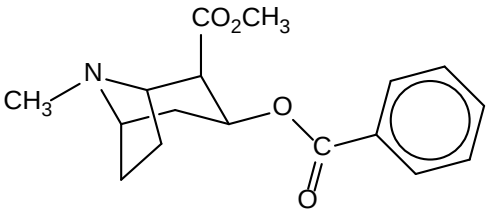
26 Antipyrine is a drug used in reducing fever. The synthesis of antipyrine involves the reaction between compound **P** and phenylhydrazine.



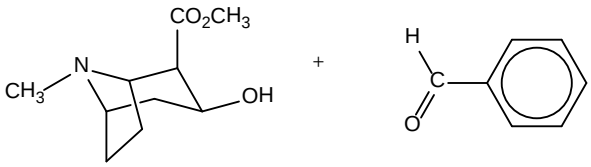
Which of the following statements regarding compound **P** is true?

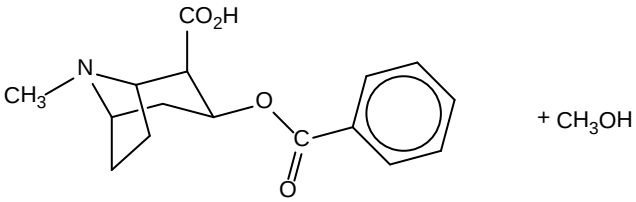
A **P** reacts with warm aqueous alkaline iodine to form one organic product.
B **P** gives a silver mirror when heated with Tollens' reagent.
C **P** turns hot acidified potassium dichromate(VI) from orange to green.
D **P** contains two carbonyl groups which can both react with cold alkaline HCN.

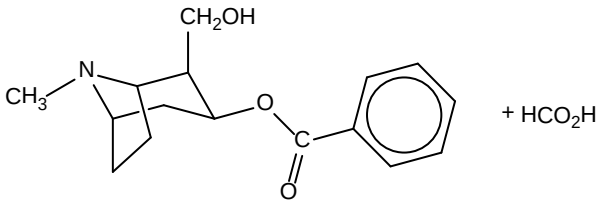
27 Cocaine is medicinally valued as a local anaesthetic. The structure of cocaine is shown below.

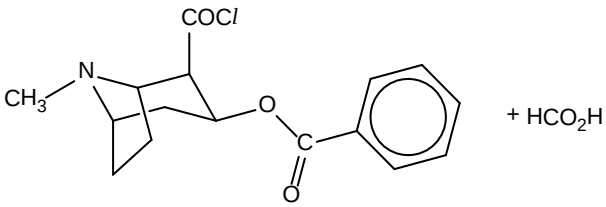


Which pair of compounds would produce cocaine when reacted together?

A 

B 

C 

D 

28 2-bromopropane, $(CH_3)_2CHBr$, **W,** may be used as the starting material for synthesising $(CH_3)_2C(OH)CO_2H$.

Which of the following sequences would result in the highest yield of $(CH_3)_2C(OH)CO_2H$?

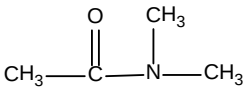
A **W** → $(CH_3)_2C(OH)CN$ → $(CH_3)_2C(OH)CO_2H$

B **W** → $(CH_3)_2CH(CN)$ → $(CH_3)_2CH(CO_2H)$ → $(CH_3)_2C(OH)CO_2H$

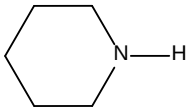
C **W** → $(CH_3)_2CH(OH)$ → CH_3COCH_3 → $(CH_3)_2C(OH)CN$ → $(CH_3)_2C(OH)CO_2H$

D **W** → $(CH_3)_2CBr_2$ → $(CH_3)_2C(Br)CN$ → $(CH_3)_2C(OH)CO_2^-$ → $(CH_3)_2C(OH)CO_2H$

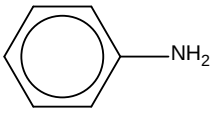
29 What is the correct order of increasing pK_b for the following four compounds?



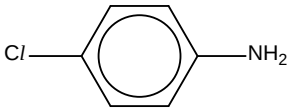
I



II



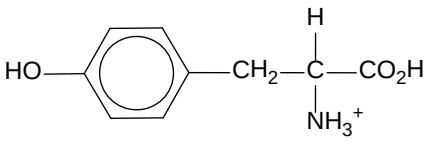
III



IV

A I, IV, III, II
B II, III, IV, I
C III, I, II, IV
D IV, III, II, I

30 Tyrosine, a building block for several neurotransmitters, has the structure as shown below. Tyrosine has three pK_a values of 2.20, 9.11 and 10.07, which correspond to the $–CO_2H$, $–NH_3^+$ and phenol groups respectively.



In an aqueous solution at pH 9.5, how much charge will be carried on different parts of each molecule of Tyrosine?

	total number of positive charges	**total number of negative charges**
A	0	1
B	0	2
C	1	0
D	1	2

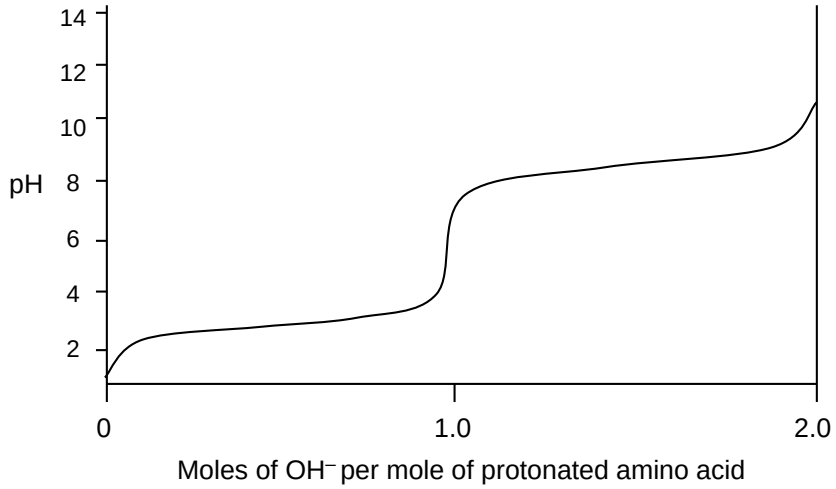
Section B

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 The titration curve of the protonated form of alanine, $NH_2CH(CH_3)CO_2H$, is as shown.



The two stages of this titration are associated with two different dissociation constants, pK_1 and pK_2.

$$H_3N^+CH(CH_3)CO_2H + OH^- \rightleftharpoons H_3N^+CH(CH_3)CO_2^- + H_2O \qquad pK_1 = 2.4$$

$$H_3N^+CH(CH_3)CO_2^- + OH^- \rightleftharpoons H_2NCH(CH_3)CO_2^- + H_2O \qquad pK_2 = 9.7$$

Which statements are correct for alanine?

1 Equal concentrations of $H_3N^+CH(CH_3)CO_2H$ and $H_3N^+CH(CH_3)CO_2^-$ are present at pH = 2.4

2 There is no net charge on alanine at the point when the slope of the curve is at maximum at its centre.

3 The form $H_2NCH(CH_3)CO_2^-$ is the major species present at pH 9.7.

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.

32 Ketones react with HCN solution in the presence of NaCN catalyst to form cyanohydrins, which are useful intermediates in organic syntheses. In investigations of the reaction between propanone and HCN, the following results were obtained.

Initial concentrations of reactants / mol dm^{-3}			Relative initial rate / mol dm^{-3} s^{-1}
$[(CH_3)_2CO]$	[HCN]	[NaCN]	
0.020	0.020	0.004	1.00
0.025	0.020	0.004	1.25
0.020	0.020	0.003	0.75
0.040	0.025	0.002	1.00

Which conclusions can be drawn about the kinetics of this reaction under these conditions?

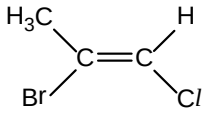
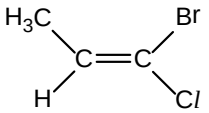
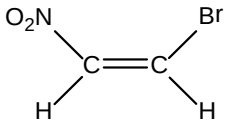
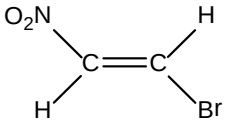
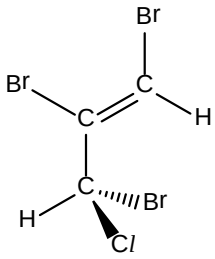
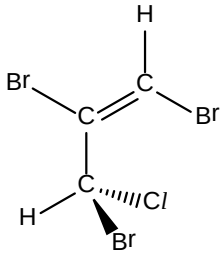
1 The reaction is zero order with respect to HCN.
2 The rate-determining step involves only propanone and NaCN.
3 When the concentration of propanone used in the reaction is in large excess, the reaction appears to be first order with respect to NaCN.

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

Which of the following are chemically stable when left to stand in the atmosphere?

1 a solution of $K_3Fe(CN)_6$
2 a solution of $CrCl_2$
3 a mixture of NaOH(aq) and $FeSO_4$(aq)

34 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		

35 Solid magnesium hydroxide is typically added to paint coatings as fire retardant to prevent spread of fire. This is possible as solid magnesium hydroxide decomposes in a similar manner to Group II nitrates.

$$Mg(OH)_2 \rightarrow MgO + H_2O$$

Magnesium hydroxide decomposes at about 300 ^oC to give water vapour which prevents oxygen from reaching the burning material. At the same time, it is an endothermic reaction that absorbs heat energy.

However, barium hydroxide is less suitable as flame retardants. Which of the following statements explain this?

1 Barium hydroxide when fully decomposed produces less amount of water vapour per mole of hydroxide, thus it is less effective.

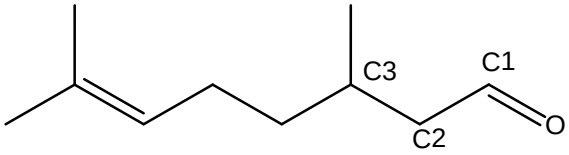
2 Barium hydroxide decomposes at a much higher temperature, therefore it may not release enough water vapour at the start of a fire.

3 Barium hydroxides are much more soluble and may not remain on the painted material for a long period of time.

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 Citronella oil is a well-known plant-based insect repellent and one of the key chemical compounds found in the oil is citronellal.



Citronellal

Which of the following statements about citronellal are correct?

1 The bond length of C1-C2 is expected to be shorter than that of C2-C3 bond due to sp^3-sp^2 overlap.

2 Optical and geometrical isomerism are both possible in citronellal.

3 Reaction of citronellal with hydrogen and a suitable catalyst will produce a compound with three chiral centres.

37 1-phenylethanol, $C_6H_5CH(OH)CH_3$, was reacted in a three-step reaction using the following reagents.

Step 1: Br_2, catalyst
Step 2: $K_2Cr_2O_7$, H^+, reflux
Step 3: HCN, NaCN, 15 °C

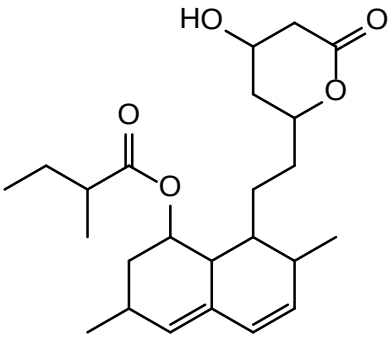
Which of the following is true?

1 The final product has no effect on plane-polarised light.

2 Iron(III) bromide can be used as a catalyst for step 1.

3 Nucleophilic substitution has occurred in step 3.

38 Lovastatin is a naturally occurring drug found in food such as oyster mushrooms and red yeast rice. It can lower cholesterol levels and thus prevent cardiovascular disease.

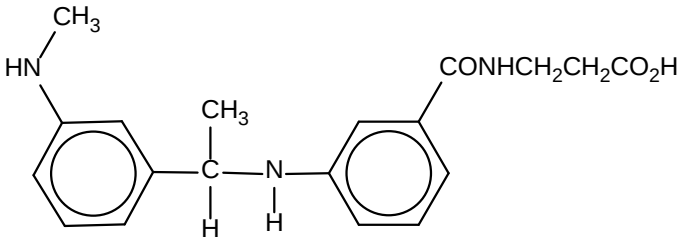


Lovastatin

Which of the following is true when lovastatin is refluxed with excess aqueous sodium hydroxide?

1 One of the organic products contains three hydroxyl groups.
2 1 mol of lovastatin reacts with 3 mol of aqueous NaOH.
3 Three organic products are formed.

39 Which of the following statements regarding compound **X** is true?



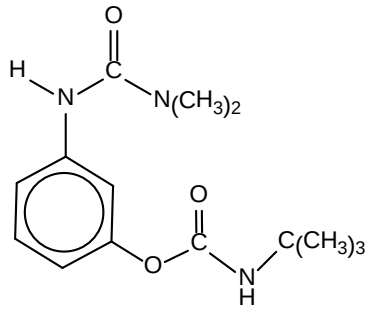
compound **X**

1 1 mol of compound **X** reacts with 3 mol of cold dilute hydrochloric acid.
2 1 mol of compound **X** reacts with 2 mol of ethanoyl chloride.
3 1 mol of compound **X** reacts with aqueous bromine to give an acidic solution.

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.

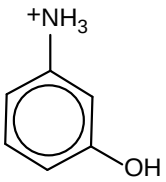
40 The structure of the herbicide *Karbutilate* is shown below.



Karbutilate

What would be the products formed when *Karbutilate* is subjected to prolonged boiling with aqueous dilute hydrochloric acid?

1 CO_2

2 

3 $(CH_3)_2NH$