ANGLO-CHINESE JUNIOR COLLEGE DEPARTMENT OF CHEMISTRY Preliminary Examination

CHEMISTRY Higher 2

9729/01

Paper 1 Multiple Choice

18 September 2019 1 hour

Additional Materials: Multiple Choice Answer Sheet Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil. Do not use staples, paper clips, glue or correction fluid. Write your name, index number and tutorial class on the Answer Sheet in the spaces provided unless this has been done for you.

There are **thirty** 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.

The use of an approved scientific calculator is expected, where appropriate.

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ANGLO-CHINESE JUNIOR COLLEGE Department of Chemistry

This document consists of 18 printed pages.

[Turn over

1 An aqueous mixture of sodium carbonate and sodium hydrogencarbonate was titrated with hydrochloric acid and the pH was recorded.

What is a suitable indicator to use for detecting the first end point and the ratio of sodium carbonate to sodium hydrogencarbonate in the mixture?



Solution

The working range of methyl orange is between pH 3.1 to 4.4 and thus is not suitable for detecting the first end point between carbonate and H^+ at a pH that is above 7. Thus thymol blue is a more suitable choice.

$\text{CO}_3^{2-} + \text{H}^+ \rightarrow \text{HCO}_3^-$

 $\text{HCO}_3^- + \text{H}^+ \longrightarrow \text{H}_2\text{CO}_3$

If 10 cm³ of H⁺ is needed to react with the carbonate ions present in solution, then the same volume of H⁺ is needed to react with the hydrogencarbonate produced after the first end point, i.e. 10 cm³. Thus the other 10 cm³ portion of H⁺ is used to react with the initial hydrogencarbonate present. Hence ratio of carbonate to hydrogencarbonate is 1:1.

Comment: Students who were not careful erroneously chose D because of the convenient 1:2 ratio that they see from the graph.

2 The most common oxidation state of americium, Am, in aqueous solution is +3.

Recently, Cu^{3+} has been shown to quantitatively oxidise $Am^{3+}(aq)$ in dilute HNO₃, while itself is reduced to Cu^{2+} .

In an experiment, 20.0 cm³ of 0.0120 mol dm⁻³ Am³⁺(aq) was found to require 24.00 cm^3 of 0.0300 mol dm⁻³ Cu³⁺ for complete oxidation.

What is the formula of the americium-containing species formed?

A AmO⁺ **B** AmO²⁺ **C** AmO_2^{2+} **D** $Am_2O_2^{2+}$

Solution

 $n(electrons) = n(Cu^{3+}) = 7.20 \times 10^{-4}$

change in oxidation state of $Am = (7.20 \times 10^{-4}) / (20.0 \times 0.0120 / 1000) = +3$

Initial oxidation state of Am = +3 + 3 = +6



3 The graph shows the second ionisation energies for ten consecutive elements.

Which of the following could be **X**?

4 Which of the following graphs are correct about a fixed amount of an ideal gas?



Solution

 \checkmark

Using the ideal gas equation, pV = nRT, $p = \frac{nRT}{V}$. Since n, R and T are constant for (1), then p has an inverse relationship with V producing a "y=1/x" graph in (1).

pV has a direct positive relationship T as seen in the ideal gas equation and thus produces a "y=x" graph in (2).

 $\frac{pV}{r}$ = nR, where nR is a constant. Thus we expect to see a "x = k" graph in (3).

5 Two single-neck round-bottomed flasks were evacuated and insulated from the surroundings. They were filled separately with gaseous ammonia and gaseous hydrogen chloride at room temperature and connected with a gas tap joint.



When the gas tap joint is opened, the two gases are allowed to mix.

What is the final pressure of the resultant gas mixture?

- A more than 3.5 atm but less than 7.0 atm
- B exactly 3.5 atm
- ✓ C more than 0.5 atm but less than 1.0 atm
 - **D** exactly 0.5 atm

Solution

 $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$ All the $NH_3(g)$ will react with HCl(g) to produce $NH_4Cl(s)$ which will deposit on the walls/bottom of the flasks. The solids' volume is negligible compared to the volume of the flasks.

5

That supposedly leaves us with 0.5 atm of HC*l*(g) in a combined volume of 500 cm³. But the reaction is exothermic and heat is given off. Since the flasks are insulated, the system will heat up and we expect the pressure of the system to be higher than 0.5 atm.

Comment: This question was poorly done with approximately half the cohort having chosen B, thinking that it was a simple mixing of the two gases.

6 When 1.00 g of ethanol was burned under a beaker of water, it was found that 100 cm³ of water was heated from 15 °C to 65 °C. The process was known to be only 70% efficient.

Use these data and values from the *Data Booklet* to calculate the enthalpy change of combustion of ethanol.

Α	-209 kJ mol ⁻¹	В	–673 kJ mol ^{–1}
С	–1373 kJ mol ^{–1}	D	+1373 kJ mol ⁻¹

Solution

 \checkmark

Heat absorbed by water = $mc \triangle T = (100)(4.18)(65 - 15) = 20,900$ Joule

Heat given out by combustion = Heat absorbed by water ÷ 0.70 = 29,857 Joule

△Hc(ethanol) = - Heat / Amount of Limiting Reagent = - 29,857 / (1 ÷ 46.0) = -1,373,000 J mol⁻¹

7 Some standard enthalpy changes are given below.

	∆ <i>H</i> ⁰ / kJ mol⁻¹
$Ca^{2+}(g) + aq \rightarrow Ca^{2+}(aq)$	-1650
$Cl^{-}(g) + aq \longrightarrow Cl^{-}(aq)$	-364
$Ca^{2+}(g) + 2Cl^{-}(g) \rightarrow CaCl_2(s)$	-2258

What is the standard enthalpy change of solution of calcium chloride?

- A +244 kJ mol⁻¹
- ✓ **B** −120 kJ mol⁻¹
 - C –2378 kJ mol⁻¹
 - D –4636 kJ mol⁻¹

Solution

 $\Delta H_{soln} = \sum \Delta H_{hyd} (Ca^{2+} + 2Cl^{-}) - LE$ = -1650 + 2(-364) - (-2258) = -120 kJ mol⁻¹

Students would have chosen A if they had only taken the ΔH_{hvd} for 1 mole of Cl⁻.

Students would have chosen C if they misinterpret ΔH_{soln} as the summation of ΔH_{hyd} values. Option D is just a summation of all three given enthalpy changes, factoring in ΔH_{hyd} for 2 moles of Cl^{-} .

8 Hydrogen peroxide reacts with acidified iodide ions, liberating iodine.

$$H_2O_2 + 2I^- + 2H^+ \rightarrow I_2 + 2H_2O$$

In the investigation of this reaction, the following results were obtained.

initial concen	trations of reacta	initial rate of formation of iodine	
[H ₂ O ₂]	[I ⁻]	[H⁺]	/ mol dm ⁻³ s ⁻¹
0.01	0.01	0.10	2.0 x 10 ⁻⁶
0.03	0.01	0.10	6.0 x 10 ⁻⁶
0.03	0.02	0.10	1.2 x 10 ^{−5}
0.03	0.02	0.20	1.2 x 10 ^{−5}

Which of the following statements are correct?

- 1 The rate equation can be written as: rate = $k [H_2O_2][I^-]$.
- 2 The reaction is second order with respect to H⁺.
- 3 The value of the rate constant is 0.2.
- ✓ A 1 only
 - B 2 only
 - **C** 1 and 2
 - **D** 1, 2 and 3

Solution

Compare Expt 1 and 2, keeping $[I^-]$ and $[H^+]$ constant, triple $[H_2O_2]$, rate triple. Order of reaction wrt H_2O_2 is ONE.

Compare Expt 2 and 3, keeping $[H_2O_2]$ and $[H^+]$ constant, double $[I^-]$, rate double. Order of reaction wrt I^- is ONE. Compare Expt 3 and 4, keeping $[H_2O_2]$ and $[I^-]$ constant, double $[H^+]$, rate constant. Order of reaction wrt H^+ is ZERO.

Rate = $k [H_2O_2] [I^-]$

Using Expt 1 data, 2.0 x $10^{-6} = k (0.01) (0.01)$ Therefore k = 0.02 mol⁻¹ dm³ s⁻¹

9 Phosphorus(V) chloride, PC*l*₅, is a white solid which sublimes at 160 °C.

When gaseous phosphorus(V) chloride is heated in a closed container, the following equilibrium is established.

$$\mathsf{PC}l_5(\mathsf{g}) \rightleftharpoons \mathsf{PC}l_3(\mathsf{g}) + \mathsf{C}l_2(\mathsf{g}) \qquad \Delta H > 0$$

Rate constant, k_b , applies for the backward reaction and equilibrium constant, K_c , applies for the overall process.

How will the values of k_b and K_c change when the equilibrium is established at a higher temperature than before?

		$k_{ m b}$	Kc
\checkmark	Α	increase	increase
	В	increase	decrease
	С	decrease	increase
	D	decrease	decrease

Solution

Increasing temperature will lead to an increase in rate of reaction because of increased frequency of effective collisions thus k_b will increase.

As the reaction is endothermic, $\Delta H > 0$, increasing temperature will favour the endothermic process to absorb the heat and thus position of equilibrium will shift to the right. POE shifting right increases K_c .

Comments: This question was poorly done, with more than half the cohort having chosen C thinking that with POE going right, $k_{\rm b}$ will decrease with no regard for the increase in temperature.

10 When gaseous phosphorus(V) chloride is heated in a closed container, the following equilibrium is established.

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$
 $\Delta H > 0$

0.0200 moles of phosphorus(V) chloride was vaporised completely in a 2.0 dm³ container. The amount of chlorine gas detected at equilibrium was found to be 0.00400 moles.

What is the value of K_c at this temperature?

A 1.0×10^{-3}

B 8.0 × 10⁻⁴

 \checkmark **C** 5.0 × 10⁻⁴

D 4.0×10^{-4}

Solution

	PCl ₅ (g)	4	PC <i>l</i> ₃ (g)	+	Cl ₂ (g)
initial / mol dm ⁻³	0.0200/2.0 = 0.0100		0		0
change / mol dm ⁻³	-0.00200		+0.00200		+0.00200
equilibrium / mol dm ⁻³	0.00800		0.00200		0.00400/2.0 = 0.00200

 $K_{\rm c} = \frac{0.00200^2}{0.0080} = 5.0 \times 10^{-4}$

Students would have chosen A if they had taken $\frac{0.00400^2}{0.0160} = 1.0 \times 10^{-3}$ Students would have chosen B if they had taken $\frac{0.00400^2}{0.0200} = 8.0 \times 10^{-4}$ Students would have chosen D if they had taken $\frac{0.00200^2}{0.0100} = 4.0 \times 10^{-4}$ Comment: Most students could get this question correct with the most

Comment: Most students could get this question correct with the most common error being A.

11 The value of pK_w at 40 °C is 13.54.

What is the pH of an aqueous solution of 0.05 mol dm⁻³ Ba(OH)₂ at 40 °C?

A 12.23

- **√ B** 12.54
 - **C** 12.70
 - **D** 13.00

Solution

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[OH^{-}] = 0.10 \text{ mol } dm^{-3}
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pOH = 1

 $pH = pK_w - pOH = 13.54 - 1 = 12.54$

- 12 In which of the following solutions will solid calcium phosphate, $Ca_3(PO_4)_2$, be the least soluble at 25 °C? The numerical value of K_{sp} of $Ca_3(PO_4)_2$ is 2.07×10^{-33} .
- ✓ **A** 0.3 mol dm⁻³ Ca(NO₃)₂ (aq)
 - **B** 0.3 mol dm⁻³ Na₃PO₄ (aq)
 - **C** 0.6 mol dm⁻³ HNO₃ (aq)
 - D water

Solution

Notice that common ion effect is involved in options A and B – the common ion being Ca^{2+} and PO_4^{3-} respectively. Option D should be ruled out straightaway once it is realized that the question is asking for the least solubility and that common ion effects are involved in options A and B.

Notice that the concentrations of Ca^{2+} and PO_4^{3-} are equal in options A and B. Hence we can look at the power of the ion's concentration in the K_{sp} expression – the larger the power the more the solubility of the salt will be decreased.

Option C actually enhances the solubility.

13 A cell diagram is written as follows:

 $Ti(s) | Ti^{2+}(aq) | H_2SO_4(aq) | SO_2(g) | Pt(s)$

Use relevant data from the Data Booklet, and the following electrode potential

 $Ti^{2+}(aq) + 2e^{-} \rightleftharpoons Ti(s)$ $E^{\circ} = -1.63V$

to calculate the standard Gibbs free energy change of the cell in kJ mol⁻¹.

A −37 B −157 C −282 D −347 √

Solution

From Data Booklet, $SO_4^{2^-} + 4H^+ + 2e \Rightarrow SO_2 + 2H_2O + 0.17$ Volt

 $E^{\circ}_{cell} = (+0.17) - (-1.63) = +1.80$ Volt

 $\Delta G = -nF E^{\circ}_{cell} = -(2)(96500)(+1.80) = -347 \text{ kJ mol}^{-1}$

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

The standard reduction potentials of some vanadium species are tabulated below.

half-reaction	E [⊕] / V
V²+(aq) + 2e⁻ ़ ∨ (s)	-1.20
V³+(aq) + e⁻ ⇒ V²+(aq)	-0.26
$VO^{2+}(aq) + 2H^{+}(aq) + e^{-} \implies V^{3+}(aq) + H_2O(I)$	+0.34

Which of the following metals, when added in excess, will reduce VO²⁺ to V³⁺?

- 1 Sn
- 2 Zn
- 3 Pb
- ✓ A 1 and 3
 - **B** 2 and 3
 - C 1 only
 - D 2 only

Solution

 E_{cell} between Sn and VO²⁺ is positive, +0.48 V. But E_{cell} between Sn and V³⁺ is negative, -0.12 V. Hence V³⁺ will be the final vanadium species.

 E_{cell} between Zn and VO²⁺ is positive, +1.10 V. E_{cell} between Zn and V³⁺ is also positive, +0.50 V. Hence V³⁺ will NOT be the final vanadium species.

 E_{cell} between Pb and VO²⁺ is positive, +0.47 V. But E_{cell} between Pb and V³⁺ is negative, -0.13 V. Hence V³⁺ will be the final vanadium species.

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

Impure copper containing traces of cobalt, iron and silver was purified via electrolysis.

Which cations of the trace metals can be found in solution?

- A Ag⁺ only
- **B** Ag⁺ and Fe²⁺
- \checkmark **C** Co²⁺ and Fe²⁺
 - D Co³⁺ and Fe³⁺

Solution

Ag⁺ + e⁻ ⇒ Ag	+0.80 V
Co ²⁺ + 2e [−] ⇒ Co	–0.28 V
Co ³⁺ + e [−] ⇒ Co ²⁺	+1.89 V
Cu ²⁺ + 2e [−] ≓ Cu	+0.34 V
Fe ²⁺ + 2e [−] ≑ Fe	–0.44 V
Fe ³⁺ + 3e [−] ≑ Fe	–0.04 V
Fe ³⁺ + e [−] ⇒ Fe ²⁺	+0.77 V

During the electrolysis of impure copper, Cu is oxidised to Cu^{2+} in solution. As such, Co and Fe will oxidise to Co^{2+} , Fe^{2+} and Fe^{3+} . It's unlikely we'd get any significant oxidation of Ag due to its electrode potential being more positive than Cu. Further oxidation of Co^{2+} to Co^{3+} is unlikely to occur too.

16 An aqueous transition metal compound, **T**, was subjected to a series of reactions.



Which statements are correct?

- 1 The anion in **S** is I^- .
- 2 The anion in **U** is SO_3^{2-} .
- 3 The anion in **V** is $CuCl_4^{2-}$
- A 1 and 2
- **B** 2 and 3
- **C** 1, 2 and 3
- ✓ D 3 only

Solution

T is CuSO₄.

Ppt formed on reaction with KI is CuI and anion in brown solution, S, is I_3^- . $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$ $I_2 + I^- \Rightarrow I_3^-$

Ppt U is BaSO₄ which does not react with HC*l*. Ba²⁺(aq) + SO₄²⁻(aq) \rightarrow BaSO₄(s)

Green solution formed is $CuCl_2$ which reacts further with more Cl^- ligands to form $CuCl_4^-$ anion complex in V.

Comment: Approximately 40% of students chose C and 40% chose the correct option D.



17 Three charts below show the variation of three physical properties for the Period 3 elements.

Which of the following is correct?

		chart 1	chart 2	chart 3		
	A ionic radius electr		electrical conductivity	melting point		
	в	electrical conductivity	melting point	ionic radius		
	С	melting point	ionic radius	electrical conductivity		
\checkmark	D	melting point	electrical conductivity	ionic radius		

Solution

Chart 1 (Melting Point): Silicon has highest mp. Na, Mg, Al as a group has the second highest mp. P_4 , S_8 and Cl_2 as a group has the lowest mp.

Chart 2 (Electrical Conductivity): Na, Mg, Al as a group has the highest electrical conductivity. Silicon is a semi-conductor. P_4 , S_8 and Cl_2 as a group has the lowest electrical conductivity.

Chart 3 (lonic Radius): Na⁺, Mg²⁺, Al³⁺ and Si⁴⁺ as a group has the smallest ionic radii. P³⁻, S²- and Cl⁻ as a group has the lowest electrical conductivity. **18** The highest oxides of the elements sodium to sulfur are added separately to water.

Which of the following diagrams best represents the pH of the solutions produced?



Solution

 Al_2O_3 and SiO_2 are insoluble in water. Hence water remains at pH = 7.

Na₂O dissolves in water to give alkaline solution of about pH = 13

MgO dissolves slightly in water to give alkaline solution of about pH = 9.

 P_4O_{10} and SO_3 dissolve in water to give acidic solution of about pH = 2.

14

19 Stability constants and colours are given in the following table for this reaction.

 $Fe(H_2O)_6^{3+} + L^- \rightleftharpoons Fe(L)(H_2O)_5^{2+} + H_2O$

ligand lg K _{stab}		colour of $Fe(L)(H_2O)_5^{2+}$		
SCN ⁻ 2.1		blood red		
F ⁻	5.4	colourless		

What would be observed when the following reagents are added to a solution of iron(III) nitrate?

- potassium fluoride
- followed by potassium thiocyanate
- A Solution turns from green to colourless, and then blood red.
- **B** Solution turns from green to colourless, and then remains colourless.
- **C** Solution turns from yellow to colourless, and then to blood red.
- ✓ **D** Solution turns from yellow to colourless, and then remains colourless.

Solution

 $Fe(H_2O)_6^{3+}$ is yellow; $FeF(H_2O)_5^{2+}$ is colourless.

Since lg K_{stab} = 5.4, F⁻ is a stronger ligand than H₂O and F⁻ will replace H₂O ligand to form FeF(H₂O)₅²⁺. Hence yellow solution turns colourless.

 $Fe(SCN)(H_2O)_5^{2+}$ is blood red.

Since Since Ig $K_{\text{stab}} = 2.1$ is smaller than Ig $K_{\text{stab}} = 5.4$, SCN⁻ is a weaker ligand than F⁻. Hence SCN⁻ will not replace F⁻. Solution remains colourless. **20** Free radical addition is a mechanism used in the synthesis of some addition polymers. Alkene monomers will polymerise in the presence of a radical initiator (In•). For instance, the synthesis of polyethene begins as such.



Which of the following chains could **not** have arisen from free radical addition?



Solution

For free radical addition to occur, students must recognise that an alkene is needed as the monomer.

A uses fluoroethene, H₂C=CHF

B uses 2-chloropropene, H₂C=C(CH₃)Cl

D uses phenylethene, (C₆H₅)CH=CH₂

There is no known monomer that can reasonably give rise to the structure in C. More accurately, it should be formed as a condensation polymer of lactic acid, 2-hydroxypropanoic acid.

Comment: Fairly well done with approximately 70% of students getting it right.

9729/01/Prelim/2019

21 Chloroethene is reacted with iodine monochloride in the presence of aqueous sodium nitrate.



Which are the major and minor products?





less stable ion



In Step 2, H_2O being the solvent, is present in large amount. H_2O has the highest chance of attacking the more stable ion to give rise to the major product.

22 The following compound Y is reacted with ethanolic sodium hydroxide.



Compound Y

Which of the following is the **major** product?



Solution

Elimination takes place when RX is heated with NaOH (in ethanol).

C-I being weaker than C-CI, will break, forming an alkene.

Zaitsev's Rule says that "more substituted alkene will be the major product". Hence tri-substituted alkene will be the major product, not the di-substituted alkene.



Which of the following statements about communes in A is correct?

- A Communesin A gives a yellow precipitate when warmed with alkaline iodine solution.
- **B** There are three tertiary amines in communes in A.
- **C** It is a planar molecule.
- \checkmark **D** One of the oxygen atoms is sp³ hybridised; the other is sp² hybridised.

Solution

Option A is deceptive because students will mistake the tertiary amide at the top left hand corner of the molecule as a methyl ketone.

Option B is deceptive because while communesin A indeed contains three amines, only two of them are actually tertiary.

Option C is out because there are many sp³ hydridised carbon atoms present in the structure of communes in A.

Option D: Do take note that it is possible to talk about the hybridization of terminal (noncentral) atoms. The ketone O is sp_2 hybridised and the O involved in the ring is sp^3 hybridised. **24** Compound **B**, C₆H₁₂O₆, is an important biomolecule abundant in the brain as it mediates cell signal transduction in response to a variety of hormones and neurotransmitters.

All the atoms (besides the hydrogen atoms) in **B** are sp^3 hybridised.

On adding excess sodium to **B**, hydrogen gas is liberated.

Which of the following statements about compound **B** is true?

- **A** Compound **B** forms a purple colouration with neutral iron(III) chloride solution.
- ✓ **B** Compound **B** forms a yellow precipitate with warmed alkaline iodine solution.
 - **C** Compound **B** forms a bright orange precipitate with 2,4-dinitrophenylhydrazine.
 - **D** Compound **B** forms a brick-red precipitate with Fehling's solution.

Solution

Option A requires a phenol. But no phenol is present in B because "all the atoms (besides the hydrogen atoms) in B are sp³ hybridised."

Option B requires a methyl ketone or a $-CH(CH_3)OH$ group. It is still possible for B to possess the latter.

Option C requires an aldehyde or ketone. But no such functional groups are present in B because "all the atoms (besides the hydrogen atoms) in B are sp³ hybridised."

Option D requires an aldehyde. But no aldehyde is present in B because "all the atoms (besides the hydrogen atoms) in B are sp³ hybridised."

25



Which statements about lactimidomycin are correct?

- 1 One mole of lactimidomycin reacts completely with four moles of 2,4-dinitrophenylhydrazine.
- 2 On reacting lactimidomycin with hot acidified KMnO₄, there is no gas evolved.
- 3 On heating lactimidomycin with KOH(aq), there is ammonia gas evolved.
- A 1 and 2
- **B** 2 and 3
- C 1 only

✓ D 3 only

Solution

Statement 1 is deceptive because only one out of the four C=O groups will undergo condensation with 2,4-dinitrophenylhydrazine. Three of these groups are actually ester and amides.

Statement 2 is wrong because carbon dioxide gas will be released; in fact four moles of it per mole of lactimidomycin.

Statement 3 involves alkaline hydrolysis. Indeed ammonia will be released from the "di-amide" (actually it is called <u>imide</u>) on the LHS of the molecule.

26 Golexanolone is a drug currently being studied for the treatment of hypersomnia.



What is the total number of stereoisomers exhibited by golexanolone?



Solution

There are seven chiral carbons – bolded in the above structure. The C=N at the top right hand corner can show cis-trans isomerism. Hence the total number of stereoisomers is 2 raised to the power of 8, which is 256.

27 Crotonaldehyde is an important biomolecule.



Which of the following statements is true about the above synthetic scheme?

- ✓ A The reaction of crotonaldehyde with hot acidified KMnO₄ produces only one organic product.
 - **B** Step **1** involves heating crotonaldehyde with NaCN in ethanol.
 - **C** Step **2a** involves the oxidation of crotonaldehyde because it gained oxygen atoms.
 - **D** NaBH₄ is the reagent used in step **2b**.

Solution

Option A: Two products are formed $- CO_2$ (which is NOT organic) and ethanoic acid.

Option B: Step 1 is nucleophilic addition. The reagents and conditions mentioned in this option is for nucleophilic substitution.

Option C: Step 2a is a hydrolysis reaction, not an oxidation reaction.

Option D: LiAlH₄ can reduce nitriles but NaBH₄ is not reducing enough for this purpose.

28 4-hydroxybenzoic acid, 2-hydroxybenzoic acid and 3,4-dihydroxybenzaldehyde share the same molecular formula.

The standard enthalpy changes of formation for 4-hydroxybenzoic acid, 2-hydroxybenzoic acid and 3,4-dihydroxybenzaldehyde are -481 kJ mol⁻¹, -493 kJ mol⁻¹ and -392 kJ mol⁻¹ respectively.



3,4-ainyaroxyber

Which of the following statements is correct?

- 1 The thermodynamic stability of these three compounds decrease in the order: 2-hydroxybenzoic acid > 4-hydroxybenzoic acid > 3,4-dihydroxybenzaldehyde
- 2 3,4-dihydroxybenzaldehyde and 4-hydroxybenzoic acid are positional isomers.
- The magnitude of the standard enthalpy change of combustion of these three compounds increase in the order:
 3,4-dihydroxybenzaldehyde < 4-hydroxybenzoic acid < 2-hydroxybenzoic acid
- ✓ A 1 only
 - B 2 only
 - **C** 1 and 3
 - **D** 2 and 3

Solution

Statement 2: They are functional group isomers.

To verify statements 1 and 3, it is best to represent both the enthalpy changes of formation and combustion in the same energy level diagram. With this combined energy level diagram, it is clear that statement 1 is true while statement 3 is false. 29 Chloroethane can be used to make sodium propanoate.

chloroethane \rightarrow **Z** \rightarrow sodium propanoate

The intermediate, **Z**, is treated with boiling aqueous sodium hydroxide to give sodium propanoate.

Which reagent would produce the intermediate, **Z**, from chloroethane?

- ✓ A potassium cyanide in ethanol
 - **B** hydrogen cyanide
 - **C** sodium hydroxide in ethanol
 - **D** alkaline KMnO₄

Solution

Recognise that the number of carbon atoms increased by 1 from chloroethane to sodium propanoate – there is a step-up reaction involving cyanide somewhere in the two steps. We seem to need to perform nucleophilic substitution on chloroethane as the first step.

Option B is the reagent for nucleophilic addition on aldehydes and ketones.

Option C is the reagent for elimination; but is there a point in converting chloroethane to ethene in this context?

Option D is the reagent for mild oxidation; but how does chloroethane actually react with it?

- **30** A polypeptide is subjected to hydrolysis by cyanogen bromide and two digestive enzymes.
 - The chemical cyanogen bromide cleaves the peptide bond at the carboxylic end of methionine (met) to give a tetrapeptide and a tripeptide.
 - The enzyme chemotrypsin hydrolyses a peptide bond at the carboxylic end of tryptophan (trp) to give two dipeptides and a tripeptide.
 - The enzyme trypsin, which hydrolyses a peptide bond at the carboxylic end of lysine (lys) to give 2 tripeptides and gly.

What is the sequence of the amino acids in this polypeptide?

- A ser-trp-lys-trp-met-lys-gly
- ✓ **B** ser-trp-lys-met-trp-lys-gly
 - **C** gly-lys-met-trp-lys-trp-ser
 - **D** gly-lys-trp-met-lys-trp-ser

Solution

"At the carboxylic end of [some amino acid]" – the RHS end of the mentioned amino acid.

Option A is out because cyanogen bromide cleaves it into a pentapeptide and a dipeptide instead. It is possible that the student think that this is the correct option if he cleaves at the LHS end of methionine.

Option C is out because trypsin does not cleave it to give glycine. In fact, instead of obtaining 2 tripeptides and glycine, we obtain two dipeptides and a tripeptide. Neither does it fit the description under chemotrypsin – there would be a tetrapeptide formed.

Option D is out because chemotrypsin cleaves it into two tripeptides and serine instead. It is possible that the student think that this is the correct option if he cleaves at the LHS end of tryptophan.

1	2	3	4	5	6	7	8	9	10
С	С	В	D	С	С	В	Α	Α	С
11	12	13	14	15	16	17	18	19	20
В	Α	D	Α	С	D	D	С	D	С
21	22	23	24	25	26	27	28	29	30
Α	В	D	В	D	В	Α	Α	Α	В