NAME		Class	

ST ANDREW'S JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

Chemistry (9729) **17 September 2018**

Paper 1 Multiple Choice **1 hour**

Additional Materials: Multiple Choice Answer Sheet, Data Booklet

READ THESE INSTRUCTIONS:

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

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.

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.

This document consists of **14** printed pages.

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
D	C	C	B	A	B	A	D	D	C

Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
D	D	D	C	A	B	C	C	A	A

Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
A	D	B	B	A	B	B	A	C	A

1 To identify an oxide of nitrogen, the oxide is mixed with an excess of hydrogen and passed over a catalyst at a suitable temperature.

$$N_xO_y \xrightarrow[\text{catalyst}]{H_2\,(g)} x\,NH_3 + y\,H_2O$$

The water collected weighs 0.133 g. The ammonia produced is neutralised by 18.50 cm^3 of 0.2 mol dm^{-3} HC*l*.

Which of the following could be the oxide?

1 N_2O

2 NO_2

3 NO_3

4 N_2O_4

A 3 only

B 1 and 2 only

C 2 and 3 only

D 2 and 4 only

Answer: D

No. of moles of water = 0.133/18 = 0.00739

No. of moles of NH_3 = 18.50/1000 x 0.2 = 0.0037

Ratio of NH_3 to water is 1: 2

Therefore, x : y (i.e. N to O) of oxide is also 1:2

2 This question is about sparingly soluble salts.

	AgC*l*	**AgI**	**HgI_2**
K_{sp}	1.0×10^{-10}	8.3×10^{-16}	1.1×10^{-21}

From the above information, which statements are **not** true?

A	For a solution containing 1 mol dm^{-3} of NaCl and NaI, the concentration of chloride ions when AgI just starts to precipitate is 1 mol dm^{-3}.
B	The solubility of HgI_2 is 6.50×10^{-8} mol dm^{-3}.
C	The solubility of HgI_2 is the lowest.
D	The units for K_{sp} for HgI_2 is $mol^3\ dm^{-9}$.

Answer: C

Option A: Since silver chloride and silver iodide has the same number of ions, the solubility is directly proportional to the K_{sp}. Hence silver iodide is precipitated before silver chloride. When silver iodide precipitates, chloride ions are still in solution and have not precipitated yet. Hence, the concentration of chloride ions is still 1 mol dm^{-3}.

Option B: Let solubility of HgI_2 be x, hence $K_{sp} = 4x^3$. $x = 6.50 \times 10^{-8}$ mol dm^{-3}

Option C: The solubility of AgCl = 1 x 10^{-5} mol dm^{-3}, AgI = 2.88 x 10^{-8} mol dm^{-3}. AgI is less soluble than HgI.

Option D: For HgI_2 $K_{sp} = [Hg^{2+}][I]^2$, hence units is $(mol\ dm^{-3})^3 = mol^3 dm^{-9}$

3 The following tests were performed on an aqueous solution containing bromide and iodide ions.

Step	Test	Observations
1	Add excess $AgNO_3$(aq).	A mixture of cream and yellow precipitate were formed.
2	To the mixture from step 1, add concentrated NH_3.	The cream precipitate dissolved to form a colourless solution. The yellow precipitate was insoluble.
3	Filter the mixture from step 2.	Filtrate was a colourless solution. Residue was a yellow solid.
4	Add Cl_2(aq) to filtrate.	Brown solution is formed.

Which of the following statements is correct?

A	In step 2, the cream precipitate dissolved because the addition of concentrated NH_3 results in formation of a complex which decreases the K_{sp} of AgBr.
B	In step 2, the yellow precipitate was insoluble because the K_{sp} of AgI is higher than the K_{sp} of AgBr.

	C	In step 2, the yellow precipitate was insoluble because the ionic product of AgI is higher than the K_{sp} of AgI.
	D	In step 4, a disproportionation reaction has taken place.
		Answer: C The yellow precipitate remained in step 2 because IP of AgI > Ksp of AgI.

4 A stable ion of **Q** has the following properties:

- has a noble gas configuration
- has more protons than electrons
- was obtained by removing electrons from the same orbital

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

A	Al	**B**	Ca	**C**	Cu	**D**	S

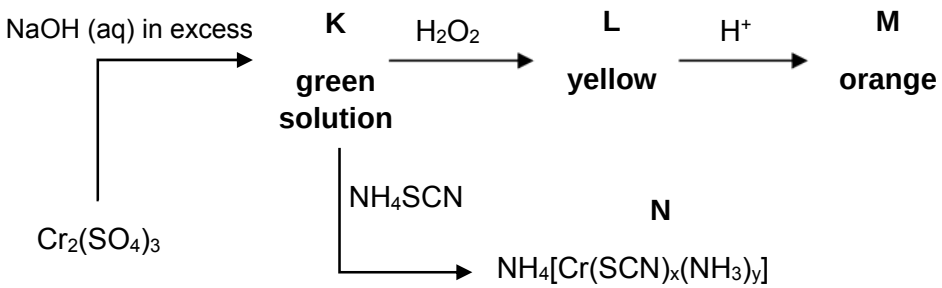
Answer: B

From the first 2 properties, **Q** has to be a main group metal.

Hence, option C and D are incorrect.

Since it was obtained by removing electrons from the same orbital, **Q** has to be either a metal in Group 1 or 2.

5 Chromium and its compounds undergo the following reactions.



N has the following composition by mass: Cr, 15.5%; S, 38.1%; N, 29.2%.

Which of the following can be deduced from the above reaction scheme?

	A	The values of x and y in **N** are 4 and 2 respectively.
	B	The types of reactions that occur are ligand exchange and redox only.
	C	The formula of **K** is $Cr(OH)_2(H_2O)_6$.
	D	H_2O_2 is a reducing agent in the conversion of **K** to **L**.
		Answer: A Option A: The empirical formula: Cr, 15.5%; S, 38.1%; N, 29.2% Cr : S : N = 0.298 : 1.19 : 2.09 = 1: 4 : 7

		From K to N, there should be no change in oxidation state and merely a ligand exchange. In N, the coordination number is 6 and the oxidation number of Cr = +3. Given that there is one cation NH_4^+, hence the overall charge is -1. Thus, There are $4SCN^-$ ligands to make the overall charge -1. Option B: The conversion of L to M is also an acid base reaction where L is CrO_4^{2-} and M is $Cr_2O_7^{2-}$. Option C: K is $Na_3[Cr(OH)_6]$ (aq). K is not a solid unlike the formula given in option C. Option D: H_2O_2 is an oxidising agent in the conversion of K to L as the oxidation number of Cr increases from +3 to +6.
6	Which one of the following statements about Group 2 elements and their compounds is correct?	
	A	Beryllium chloride has a higher boiling point than magnesium chloride as it has a more exothermic lattice energy than magnesium chloride.
	B	The reducing power of Group 2 elements increases down the group.
	C	1 mole of barium carbonate, on heating over a short period of time, decomposes to give more carbon dioxide gas than 1 mole of magnesium carbonate.
	D	Barium has a higher melting point than magnesium due to more electrons.
		Answer: B Option A: Beryllium chloride is a simple covalent molecule while magnesium chloride is an ionic compound. Hence beryllium chloride should have a lower boiling point as it has weaker id-id interactions than the strong ionic bonds in magnesium chloride. Option B: The E^{θ} value for M^{2+} / M is more negative down the group, indicating M is more easily oxidised hence its reducing power increases down the group. Option C: Ba^{2+} has a smaller charge density than Mg^{2+} and distorts electron cloud of CO_3^{2-} to smaller extent, hence C – O bond is weakened to a smaller extent and more energy is required to decompose $BaCO_3$. Hence, less CO_2 is given off when $BaCO_3$ is decomposed. Option D: Ba and Mg are both metallic with strong electrostatic forces of attraction between metal cation and sea of delocalised electrons. The number of electrons in the sea of delocalised electrons would be the same as both lose 2 valence electrons per atom. Ba^{2+} has a smaller charge density so the metallic bonds are weaker and less energy required to break them. Barium should have a lower melting point.
7	Liquefaction can be defined as a process that generates a liquid from a gas and this can be done by altering pressure. In the liquefaction of CH_4 and NH_3, the pressure needed for NH_3 is less than CH_4.	

Which of the following reasons best explains this observation?

A NH_3 has stronger intermolecular forces of attraction than CH_4.

B NH_3 has weaker bond energy than CH_4.

C NH_3 molecules are bigger than CH_4 molecules.

D NH_3 molecules possess less kinetic energy than CH_4 molecules.

Answer: A

The process of liquefaction is making the molecules of gas come closer together via pressurisation. If the intermolecular forces between the molecules are stronger, the pressure required would be less. Since NH_3 has hydrogen bond and is stronger than instantaneous dipole-induced dipole in CH_4, pressure needed for NH_3 would be less than CH_4.

8 Phosphate buffers are commonly used in biological chemistry research.

$$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+ \qquad pK_a = 6.7$$

A phosphate buffer with pH 7.4 was prepared using NaH_2PO_4 and Na_2HPO_4 solutions. The total hydrogen phosphates concentration ($[HPO_4^{2-}] + [H_2PO_4^-]$) of the buffer was 0.3 mol dm^{-3}.

What are the concentrations of NaH_2PO_4 and Na_2HPO_4 used to create this buffer?

	$[NaH_2PO_4]$ / mol dm^{-3}	$[Na_2HPO_4]$ / mol dm^{-3}
A	0.23	0.07
B	0.07	0.23
C	0.10	0.50
D	0.05	0.25

Answer: D

$pH = pK_a + \lg [Na_2HPO_4]/ [NaH_2PO_4]$

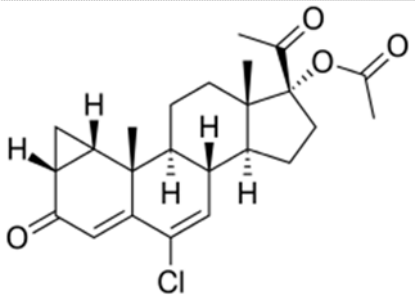
Hence, $7.4 = 6.7 + \lg [Na_2HPO_4]/ [NaH_2PO_4]$

$7/10 = \lg [Na_2HPO_4]/ [NaH_2PO_4]$

$[Na_2HPO_4]/ [NaH_2PO_4] = 5$

Hence, the answer can be C or D. However, since the $([HPO_4^{2-}] + [H_2PO_4^-])= 0.30$, thus D is the answer.

9 Cyproterone acetate (CPA) is a drug that is used in the treatment of prostate cancer.



CPA

Which of the following statements about CPA are incorrect?

1	One mole of silver is formed when one mole of CPA is warmed with $[Ag(NH_3)_2]^+$.
2	Two moles of yellow precipitate is formed when one mole of CPA is warmed with alkaline iodine solution.
3	One mole of silver chloride is formed when one mole of CPA is heated with ethanolic silver nitrate.

A	1 only	**B**	1 and 2 only	**C**	2 and 3 only	**D**	1, 2 and 3

Answer: D

Statement 1: False. No aldehyde is present.

Statement 2: False. Only one mole of yellow precipitate is formed when one mole of CPA is subjected to iodoform test.

Statement 3: False. C*l* forms a partial double bond with C=C. Hence it does not undergoes hydrolysis with $AgNO_3$

10 Consider the following equilibrium:

When Q_2 is allowed to react with R_2 in a molar ratio of 2:1 at a total initial pressure of 3 atm, 20% of the equilibrium mixture is found to be Q_2R.

What is the equilibrium constant, K_p, of this reaction?

A	0.0174 atm^{-1}
B	0.0781 atm^{-1}
C	0.194 atm^{-1}
D	0.232 atm^{-1}

Answer: C

Since total pressure is 3 atm and the mole ratio between Q_2 and R_2 is 2:1, their respective partial pressure is 2 atm and 1 atm.

$$2Q_2\,(g) + R_2\,(g) \rightleftharpoons 2Q_2R(g)$$

Initial:	2	1	0
change:	-2x	-x	+2x
equilibrium:	2 - 2x	1 – x	2x

Total pressure of gas at equilibrium = (2-2x)+(1-x) +2x = 3-x

According to question,

$2x/(3-x) = 0.20$

$x = 0.273$ atm

Thus,

partial pressure of $Q_2 = 2 – 2(0.273) = 1.454$ atm

partial pressure of $R_2 = 1 - 0.273 = 0.727$ atm

partial pressure of $Q_2R = 2 \times 0.273 = 0.546$ atm

$K_p = (0.546)^2 / [(1.454)^2(0.727)] = 0.194\ atm^{-1}$

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

Iodine clock reaction can be used to study how the concentration of iodide ions affect the rate of oxidation of iodide ions with peroxodisulfate ions. Peroxodisulfate ions convert iodide ions into iodine slowly.

$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$

The rate of the reaction can be increased by the addition of catalysts such as aqueous iron (III) ions.

A possible catalysed reaction pathway involves the following steps:

Step 1: $2Fe^{3+}(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Fe^{2+}(aq)$

Step 2: $S_2O_8^{2-}(aq) + 2Fe^{2+}(aq) \rightarrow 2SO_4^{2-}(aq) + 2Fe^{3+}(aq)$

Which of the following statements are **correct**?

1	Aqueous cobalt(II) ions can be used as a catalyst in this reaction.
2	$S_2O_8^{2-}$ is a stronger oxidising agent than Fe^{3+}.
3	The $E_{cell}^{\ominus}$ for step 2 is more positive than step 1.

A	2 only	**B**	1 and 3 only	**C**	2 and 3 only	**D**	1, 2 and 3

Answer: D

$Co^{3+} + e \rightleftharpoons Co^{2+}$ + 1.89

$Fe^{3+} + e \rightleftharpoons Fe^{2+}$ + 0.77

$S_2O_8^{2-}$ + 2e ⇌ $2SO_4^{2-}$ + 2.01

I_2 + 2e ⇌ $2I^-$ + 0.54

Statement 1:

Step 1: $2Co^{2+}(aq) + S_2O_8^{2-}(aq) \rightarrow 2Co^{3+}(aq) + 2SO_4^{2-}(aq)$

Step 2: $2I^-(aq) + 2Co^{3+}(aq) \rightarrow I_2(aq) + 2Fe^{3+}(aq)$

$E_{cell}^{\ominus}$ for step 1: 2.01 – 1.89 = +0.12 V

$E_{cell}^{\ominus}$ for step 2: 1.89 – 0.54 = +1.35 V

Statement 2:

$S_2O_8^{2-}$ is a stronger oxidising agent than Fe^{3+} as it is more easily reduced due a more positive reduction potential +2.01 vs + 0.77 V.

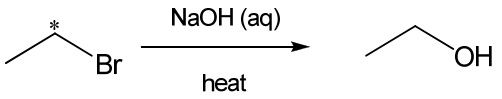
Statement 3:

$E_{cell}^{\ominus}$ for step 1: 0.77 – 0.54 = +0.23 V

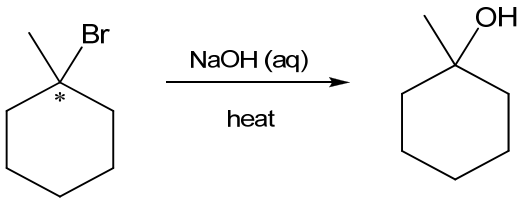
$E_{cell}^{\ominus}$ for step 2: 2.01 – 0.77 = +1.24 V

12 Which of the following reactions has no change in the hybridisation state of the carbon atom indicated with an asterisk (*) from the reactant to the **intermediate** in the mechanism?

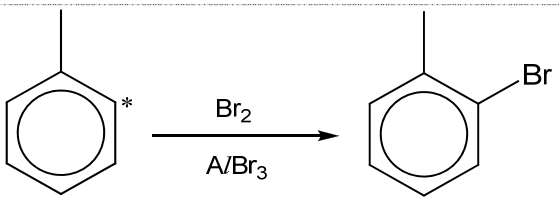
A



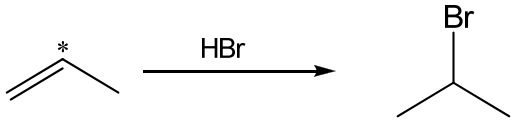
B



C



D

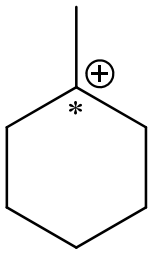


Answer: D

Option A: C atom with * is sp^3 hybridised in the reactant. Nucleophilic substitution (S_N2) mechanism as it is a primary RX. There is no intermediate. The product is formed via a transition state (C atom with * will not be sp^3 hybridised anymore because it is bonded to 5 groups).

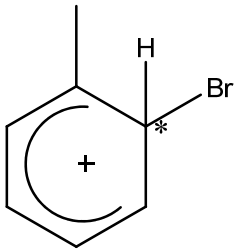
Option B: C atom with * is sp^3 hybridised in the reactant. Nucleophilic substitution (S_N1) mechanism as it is a tertiary RX. Intermediate is a carbocation where the C atom with * is sp^2 hybridised.

Intermediate:



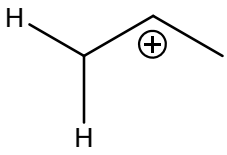
Option C: C atom with * is sp^2 hybridised in the reactant. Electrophilic substitution mechanism. The C atom with * in the intermediate is sp^3 hybridised.

Intermediate:



Option D: C atom with * is sp^2 hybridised in the reactant. Electrophilic addition mechanism. The C atom with * in the intermediate is also sp^2 hybridised.

Intermediate:



13 What is the volume of vapour formed when 10 cm^3 of liquid ethanol (density: 0.789 g cm^{-3}) is heated to 300 °C at a pressure of 5 bar?

A 85.5 cm^3

B 855 cm^3

C 163.3 cm^3

D 1633 cm^3

Answer: D

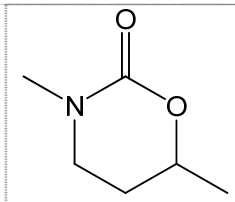
Mass of ethanol = 10 x 0.789 = 7.89

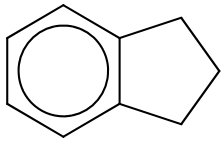
No. of moles of ethanol = 7.89/46 = 0.1715

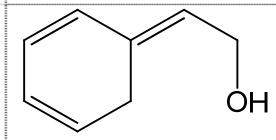
Therefore, using pV = nRT,

V = [0.1715 x 8.31 x (300+273)] / (5 x 10^5) = 0.001633 m^3 = 1633 cm^3

14 Which compounds liberate carbon dioxide gas when heated with acidified potassium manganate(VII)?

1 

2 

3 

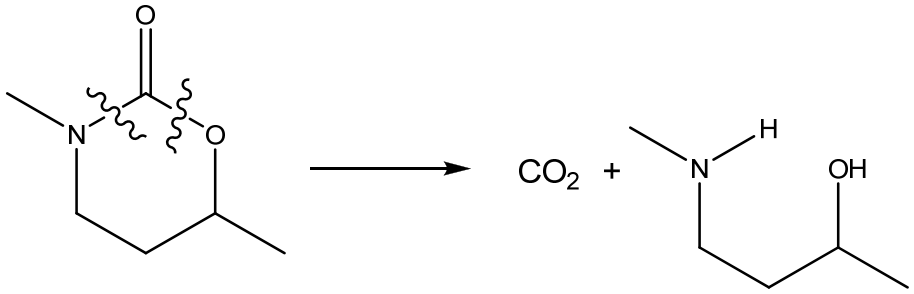
A 1 and 2 only

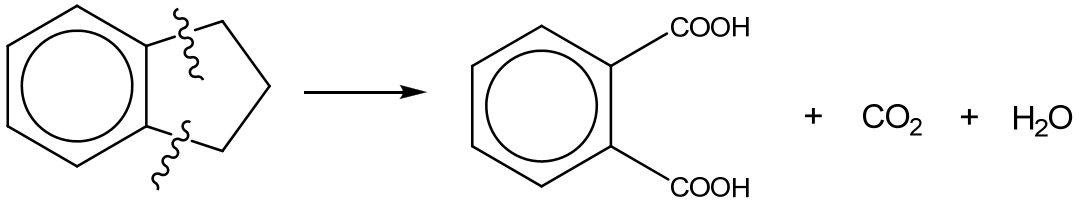
B 2 and 3 only

C 1, 2 and 3

D None of the above

Answer: C

1: 

2: 

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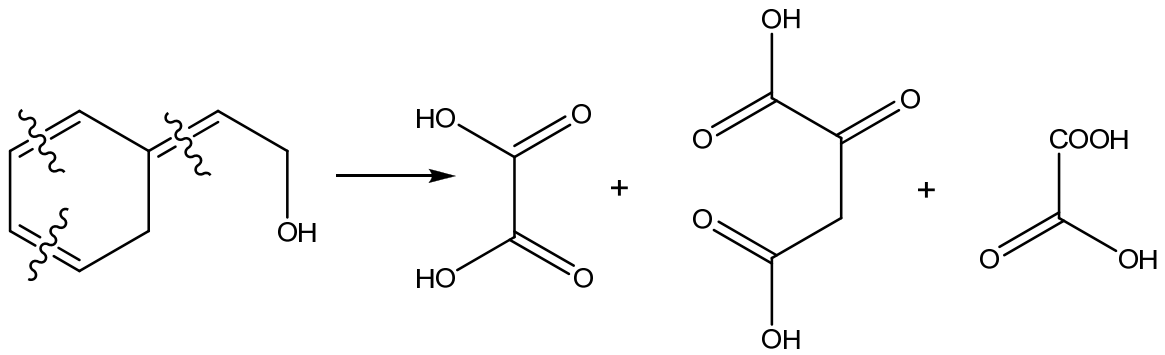

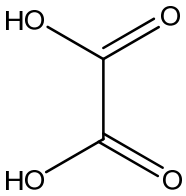

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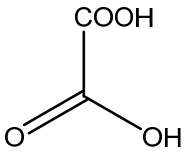


are further oxidised to CO_2 and H_2O

15 Trifluorooxonium has the formula OF_3^{n+} and its shape is trigonal pyramidal.

What is the value of *n* in trifluorooxonium?

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

Answer: A

Since its shape is trigonal pyramidal, that must mean that around O there are 3 bp and 1lp. The 3 bp are formed between one electron from F and 1 from O and the lp belongs to O. With only 5 valence electrons around O than the usual 6, the entire ion is short of 1 electron and hence n = 1

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

Which set of reagents, when added in the order shown below, would convert $Fe^{3+}(aq)$ to $[Fe(CN)_6]^{3-}(aq)$?

$$Fe^{3+}(aq) \xrightarrow{\text{step 1}} Fe^{2+}(aq) \xrightarrow{\text{step 2}} \mathbf{X} \xrightarrow{\text{step 3}} [Fe(CN)_6]^{3-}(aq)$$

	step 1	step 2	step 3
A	Zn(s)	$CN^-(aq)$	$SO_2(g)$
B	$I^-(aq)$	$CN^-(aq)$	$Cl_2(g)$
C	$H_2O_2(aq)$	$I^-(aq)$	$CN^-(aq)$
D	Ag(s)	$I^-(aq)$	$CN^-(aq)$

Answer: B

Step 1: redox

$2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2 \quad E^{\ominus}_{cell} = +0.77 - (+0.54) > 0\ V$

Step 2: ligand exchange

$Fe(H_2O)_6^{2+} + 6CN^- \rightarrow Fe(CN)_6^{4-} + 6H_2O$

Step 3: redox

$Fe(CN)_6^{4-} + \frac{1}{2}CI_2 \rightarrow Fe(CN)_6^{3-} + CI^-$

$E^{\ominus}_{cell} = +1.36 - (+0.36) > 0\ V$

For **A**, step 3 is incorrect as SO_2 cannot be reduced by $Fe(CN)_6^{4-}$.

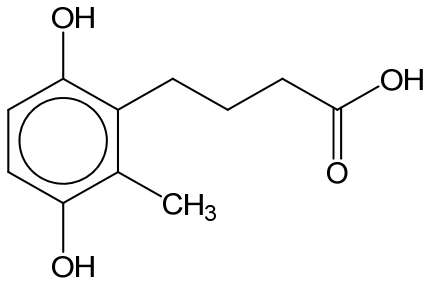
For **C**, step 2 is incorrect as Fe^{2+} is oxidised to Fe^{3+} while I^- cannot be reduced.

For **D**, step 1 is incorrect as reaction is not feasible since $E^{\ominus}_{cell} = +0.77 - (+0.80) < 0$ V.

Step 2 is incorrect as Fe^{2+} is oxidised to Fe^{3+} while I^- cannot be reduced.

17 Compound **X** is dissolved in heavy water, D_2O. It contains a number of hydrogen atoms which can be easily be replaced by deuterium, D.

[D, deuterium = ^2H]



Compound **X**

What is the maximum number of hydrogen atoms which could be replaced by deuterium atoms in each molecule of **X**?

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

Answer: C

Phenol and carboxylic acid will dissociate in water to form O^- and COO^- respectively.

$D_2O \rightleftharpoons D^+ + OD^-$

The D^+ can bond with the phenoxide ions and carboxylate ion. Since there are 2 phenols and 1 carboyxlic acid in compound **X**, 3 hydrogen atoms could be replaced.

18 Which of the following, when mixed together at 298K and 1 bar, represent the standard enthalpy change of neutralisation?

1	500 cm^3 of 1 mol dm^{-3} HNO_3 and 500 cm^3 of 1 mol dm^{-3} KOH
2	500 cm^3 of 1 mol dm^{-3} H_2SO_4 and 500 cm^3 of 1 mol dm^{-3} $Ca(OH)_2$
3	1 dm^3 of 1 mol dm^{-3} HNO_3 and 500 cm^3 of 1 mol dm^{-3} $Ca(OH)_2$
4	1 dm^3 of 1 mol dm^{-3} H_2SO_4 and 1 dm^3 of 1 mol dm^{-3} KOH

A 1 only **B** 2 and 3 only **C** 2, 3 and 4 only **D** 1, 2, 3 and 4

Answer: C

Standard enthalpy change of neutralisation is when 1 mole of water is produced.

Option 1 produced 0.5 moles of water while the other options produce 1 mole of water.

19 Which of the following cannot act as a ligand?

A AlH_4^-

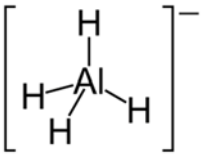
B N_2H_4

C CH_3OH

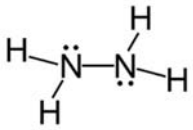
D CO

Answer: A

Option A: No available lone pair for dative bonding



Option B:



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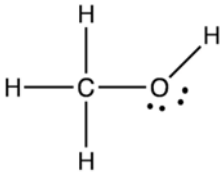
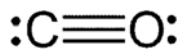
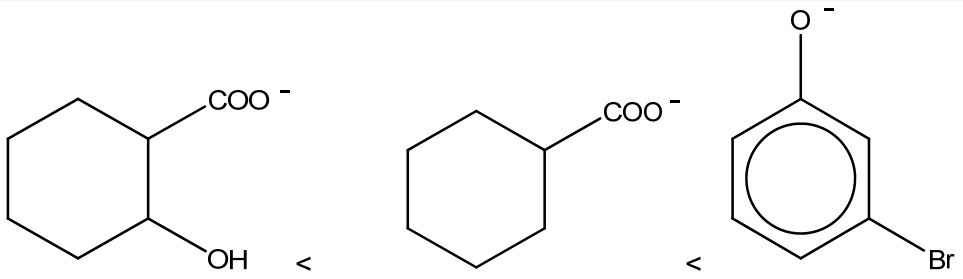
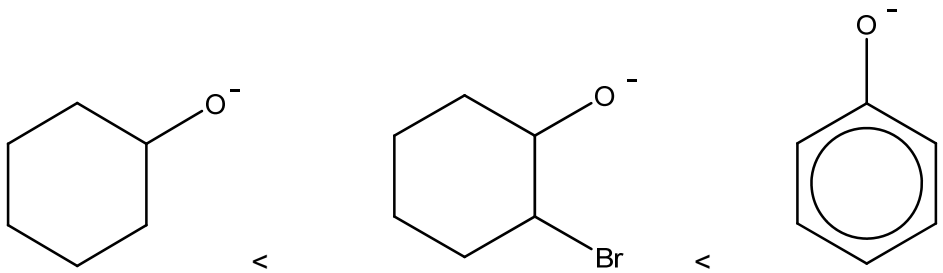
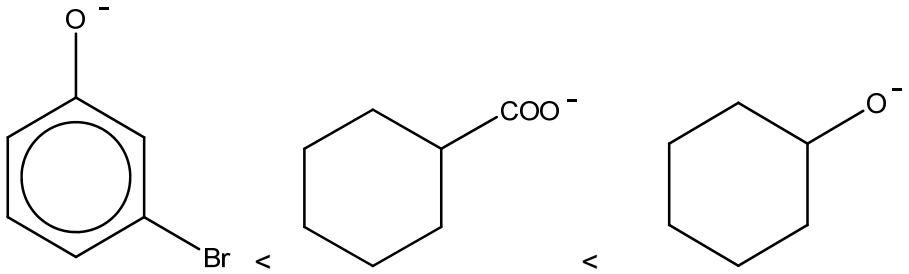
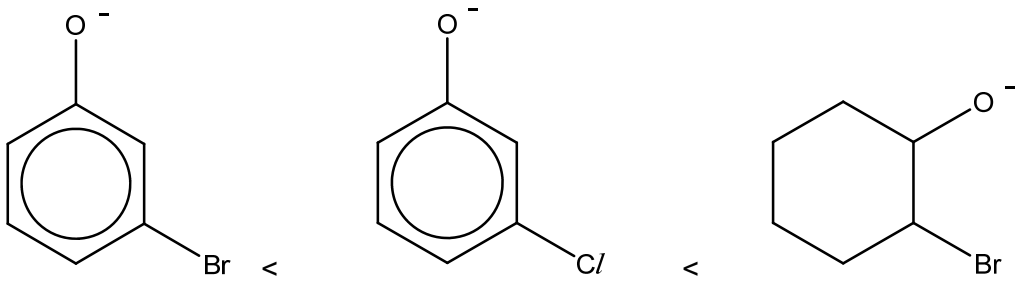


Option D:



20 Which of the following shows an increasing trend in K_b ?

	A	
	B	
	C	
	D	
		Answer: A Increasing trend in K_b = increasing basicity = increasing strength of conjugate base = decreasing acidity of the original acid. Carboxylic acids are stronger acids than phenols which are stronger acids than alcohols. Hence the carboxylate ions are the weakest conjugate bases, followed by phenoxide ions, followed by alkoxide ions which are the strongest conjugate bases. Option A: OH is electron withdrawing group which stabilises the conjugate base further, hence the negative charge does not accept H^+ readily, thus it's the weakest base. Option B: Alkoxide ions are supposed to stronger conjugate bases than phenoxide ions. Option C: Phenoxide ions are supposed to be stronger conjugate bases than carboxylate ions.

Option D: C*l* is more electronegative than Br, hence the negative charge on O is less available to accept H^+ when C*l* is attached to the ring compared to Br.

21 Which quantity would best indicate the strength of intermolecular hydrogen bonds in HF?

A enthalpy change of vapourisation

B enthalpy change of formation

C enthalpy change of atomisation

D bond dissociation energy

Answer: A

Hydrogen bond is only formed between HF and NH_3 when dissolve in water. The other 3 energy change involved breaking and forming of other kinds of bonds (e.g. covalent bond) and not the hydrogen bond.

22 The following data refer to cobalt as a typical transition element and calcium as an s-block element. Which of the following properties shows the correct data for both elements?

	Property	Cobalt	Calcium
A	Metallic radius / nm	0.150	0.117
B	Electrical conductivity / relative units	10.2	50
C	Melting point / °C	1495	1965
D	Density / g cm^{-3}	8.9	1.54

Answer: D

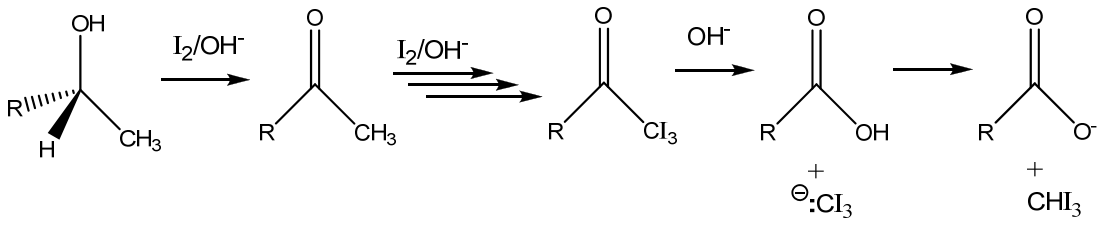
Option A: Co has more protons than Ca, hence the nuclear charge is higher than Ca. Co also has more electrons than Ca but the increase in shielding effect is minimal. Although the additional 2 electrons in Co are added in an inner sub-shell, they still provide a relatively poor shielding for the outermost 4s electrons. Hence, the valence 4s electrons in Co experiences a greater effective nuclear charge and are attracted more strongly to the nucleus than those in Ca, resulting in a smaller radius.

Option B: Cobalt should have higher conductivity than calcium due to more delocalised electrons from 3d and 4s.

Option C: Cobalt should have higher m.p than calcium. For cobalt, both 3d and 4s electrons are delocalised to form a 'sea' of electrons for strong metallic bonding. Hence, strong electrostatic forces holding the metallic cations (which has a larger cationic charge and smaller cationic radius) together.

Option D: While the size of the atom, measured by the metallic radius, decreases slightly from scandium to zinc, the relative atomic mass increases considerably. This results in an increase in density from scandium to zinc. The d-block metals are, in general, denser than the s-block metals.

23 The reaction of methyl alcohols with alkaline aqueous iodine can be described by the simplified scheme as shown below:



Which of the following reactions have taken place?

1	Oxidation
2	Acid-base reaction
3	Nucleophilic addition

A 1 only **B** 1 and 2 only **C** 1 and 3 only **D** 1, 2 and 3

Answer: B

Statement 1: Iodoform test is an oxidation reaction. Alcohol is oxidised to a carboxylic acid (carboxylate).

Statement 2: Acid-base reaction occurs in the last step where CI_3^- acts as base to accept H^+ from OH in RCOOH (which acts as acid).

Statement 3: There is no addition reaction taking place.

24 Nitrogen, ^{14}N, is the final product formed by the radioactive decay of ^{14}C, which is a first-order reaction with a half-life of 5.73×10^3 years.

What would be the age of a substance, originally nitrogen free, in which the molar proportion of ^{14}C : ^{14}N is 2 : 5?

A 0.29×10^4 years

B 1.04×10^4 years

C 1.58×10^4 years

D 1.95×10^4 years

Answer: B

Original amount of ^{14}C is 7 parts (2+5).

Since radioactive decay of ^{14}C is first order,

$2/7 = (1/2)^n$ where n is the no. of half-life that took place for ^{14}C.

n =1.807

Therefore, age of the substance is $1.807 \times 5.73 \times 10^3 = 1.04 \times 10^4$ years.

25 The properties of the oxides of four Period 3 elements **W, X, Y** and **Z** are given below.

- The oxide of **W** is insoluble in water and in dilute acid but soluble in concentrated sodium hydroxide.
- The oxide of **X** is amphoteric.
- The oxide of **Y** reacts with dilute potassium hydroxide at room temperature.
- The oxide of **Z** dissolves in water to form a solution of pH = 13.

Which of the following is correct in order of increasing atomic number?

A **Z, X, W, Y**

B **W, X, Y, Z**

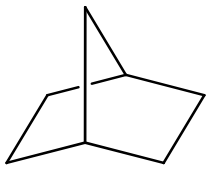
C **Z, W, X, Y**

D **Z, Y, W, X**

Answer: A

W is Silicon. X is Aluminium. Y is either Phosphorus or Sulfur. Z is Sodium.

26 Norcarane undergoes free radical substitution with limited bromine in the presence of ultraviolet light to form mono-brominated compound **Y**.

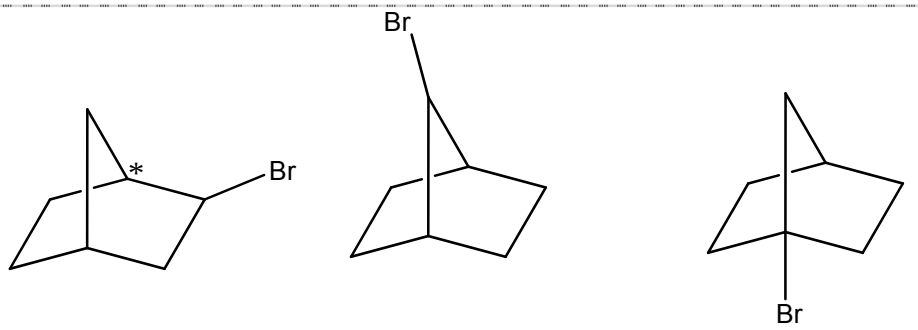


Norcarane

How many isomers of **Y** (including stereoisomers) will be formed at the end of the reaction?

A 3 **B** 4 **C** 6 **D** 8

Answer: B



There are 3 structural isomers. One of them has a chiral carbon (C*) so there are 4 isomers including stereoisomers.

27 The following are information for a reaction involving **X** and **Y**:

- it is first order with respect to [**X**] and zero order with respect to [**Y**].
- its rate constant doubles for each 10 °C rise in temperature

Which of the following statements are true about this reaction?

1	The half-life of the reaction remains the same when [**X**] doubles.
2	The half-life of the reaction doubles when [**Y**] is halved.
3	When the temperature of the reaction increases from 298K to 318K, the rate of the reaction will be quadrupled.
4	The rate of the reaction will change when [**X**] is halved and temperature increases from 298K to 308K.

A	1 and 2 only	**B**	1 and 3 only	**C**	1, 2 and 3 only	**D**	2, 3 and 4 only	

Answer: B

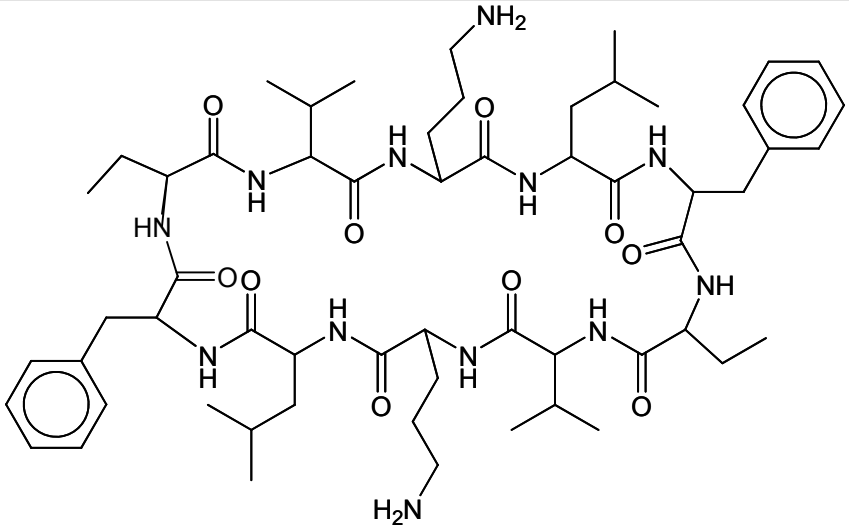
Statement 1 is correct as half-life is not affected by change in [X].

Statement 2 is wrong as [Y] does not affect the rate of reaction at all.

Statement 3 is correct as temperature increased by 20 °C and that would cause rate to increase 4 times.

Statement 4 is wrong as rate will not change due to it decreased 2 times due to [X] is halved but increase 2 times due to temperature increase by 10 °C.

28 Gramicidin Soviet is an antibiotic that is effective against some fungi. It is made up of several α amino acids.



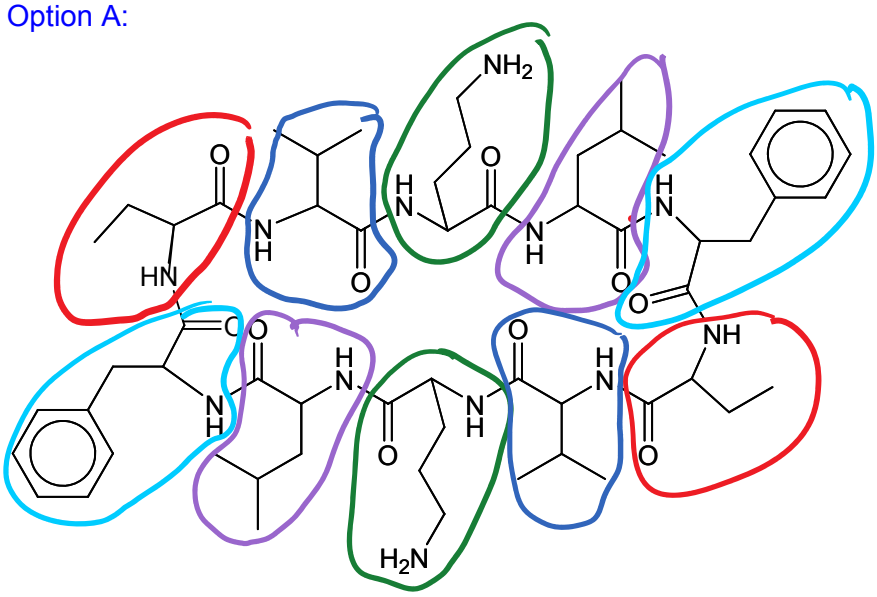
Gramicidin Soviet

Which statement about Gramicidin Soviet is correct?

A	It is made up of 5 different amino acids.
B	1 mole of Gramicidin Soviet consists of 9 amide bonds.
C	1 mole of Gramicidin Soviet reacts with 10 moles of hot dilute H_2SO_4.
D	Upon reaction with hot dilute NaOH, the products formed have high melting point as they can form strong intermolecular hydrogen bonding.

Answer: A

Option A:



Gramicidin Soviet

There are 5 different amino acids (marked by the different colours).

Option B: There are 10 amide bonds.

Option C: 10 moles of amide bonds will be hydrolysed by 10 moles of hot dilute H_2SO_4. However, there are amine groups in the side-chains which would also be neutralised by

dilute H_2SO_4. Hence, more than 10 moles of hot dilute H_2SO_4 will react with 1 mole of Gramicidin Soviet.

Option D: Upon reaction with hot dilute NaOH, the products formed are ionic salts (the COOH groups obtained after hydrolysis of amide bonds will be neutralised to form COO^-). These salts have high melting point as they can form strong electrostatic forces of attraction between ions, and NOT form intermolecular hydrogen bonding.

29 A humidity meter is made by soaking filter paper in an aqueous solution of cobalt(II) ions in HC*l* (aq). The equation for the equilibrium reaction can be represented as follows:

$$\underset{\text{pink}}{Co^{2+}(aq)} + 4Cl^-(aq) \rightleftharpoons \underset{\text{blue}}{CoCl_4^{2-}(aq)} \qquad \Delta H = +ve$$

Which of the following statements are correct?

1	On a very humid day, the filter paper will appear more pink.
2	When the filter paper is diluted with more water, there will be no colour change.
3	On a very hot day, the filter paper will appear more blue.
4	When the filter paper is placed in a sealed container under high pressure, there will be no colour change.

A	3 only	**B**	2 and 4 only	**C**	1, 3 and 4 only	**D**	2, 3 and 4 only

Answer: C

Statements 1 and 2: When humidity increase and solution is diluted, amount of water increases and all the ions will be diluted. Since reactants have 5 ions and product only has 1 ion, the concentration of reactants will drop more than the products. Hence, by LCP, equilibrium position will shift to the left and the filter paper will appear more pink. Thus statement 1 is correct but not statement 2.

Statement 3: it is correct as on a hot day, temperature increase and by LCP, equilibrium position will shift to the right to favor the endothermic reaction to absorb the excess heat and hence the filter paper will appear more blue.

Statement 4: since pressure only affects gaseous species and there are no gaseous species in this reaction, equilibrium position is not affected and hence there is no colour change.

30 The position of equilibrium lies to the right in each of these reactions.

Reaction 1: $N_2H_4 + HBr \rightleftharpoons N_2H_5^+ + Br^-$

Reaction 2: $N_2H_5^+ + NH_3 \rightleftharpoons NH_4^+ + N_2H_4$

Based on this information, which statements are correct?

1 Br^- is the conjugate base of HBr.

2 $N_2H_5^+$ is the Bronsted base in **Reaction 2**.

3 The order of acid strength is HBr > $N_2H_5^+$ > NH_4^+.

4 N_2H_4 is the Lewis acid in **Reaction 1**.

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

Answer: A

Statement 1: HBr is a bronsted acid as it donates a proton. Hence the **product formed (bromide ion) is a conjugate base.**

Statement 2: $N_2H_5^+$ is the Bronsted acid in **Reaction 2 as it donates a proton**.

Statement 3: Since the POE lies to the right for both reactions, HBr is a stronger acid than $N_2H_5^+$ from Reaction 1 as it prefers to donate a proton. Likewise for Reaction 2 where $N_2H_5^+$ is a stronger acid than NH_4^+.

Statement 4: N_2H_4 is the Lewis base in **Reaction 1** as it donates a lone pair of electrons for dative bonding to a proton from HBr.

~ END OF PAPER ~