Catholic Junior College

JC 2 Preliminary Examinations

Higher 2

CANDIDATE NAME	
CLASS	**2T**

CHEMISTRY

9729/01

Paper 1 Multiple Choice

Tuesday 3 September 2019

1 hour

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

WORKED SOLUTIONS

1 In a titration experiment, 15 cm^3 of 0.10 mol dm^{-3} phosphorous acid, H_3PO_3 was found to react with 10 cm^3 of 0.30 mol dm^{-3} sodium hydroxide. Using this information, deduce the formula of the salt formed in this neutralisation process.

A NaH_2PO_3 **C** Na_3PO_3

B Na_2HPO_3 **D** Na_3PO_4

Concept: MCS, Acid-base reaction
Answer: B

Amount of H_3PO_3 used in experiment = 0.015 x 0.10 = 1.50×10^{-3} mol

Amount of NaOH neutralised = 0.010 x 0.30 = 3.00×10^{-3} mol

$H_3PO_3 \equiv 2$ NaOH

2 mol of NaOH neutralise 2 mol of H^+

1 mol of H^+ is left unreacted in 1 mol H_3PO_3 (since $H_3PO_3 \equiv 3H^+$)

Salt formed contains 1 mol of H^+

2 50 cm^3 of a mixture of ethene and propane gas were exploded in excess oxygen. The volume of the residual gases was found to be 200 cm^3. On being shaken with potassium hydroxide, the final volume was found to be 90 cm^3. What is the composition of the mixture? *(All volumes are measured at r.t.p)*

	volume of ethene	volume of propane
A	10	40
B	20	30
C	30	20
D	40	10

Concept: MCS, calculations involving volume of gases (involving hydrocarbons)
Answer: D

$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$

Let vol of ethene (C_2H_4) be x.

$\therefore$ vol of propane (C_3H_8) = 50 - x

Vol of CO_2 gas formed in total = $2x + 3(50 - x) = 150 - x$

Change in vol of residual gases after passing through KOH = vol of CO_2 formed

= 200 – 90 = 110 cm^3

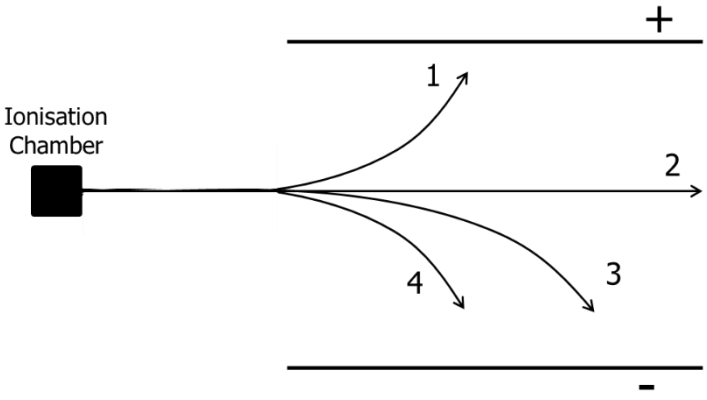
Hence, $150 - x = 110$

x = 40 cm^3 Vol of ethene = 40 cm^3 ; vol of propane = 10 cm^3

3 Plutonium-239 is a radioactive substance that emits a constant stream of α–particles which are similar to the nucleus of ^4He.

Rubidium-87 is another radioactive substance that emits β–particles which can be considered as electrons.

A small amount of Plutonium-239 and Rubidium-87 are separately placed in an ionisation chamber to emit a constant stream of radiation and the emitted particles are passed through an electric field.



What would be the path of the emitted particles in the electric field?

	Plutonium-239 (α–particles)	Rubidium-87 (β–particles)
A	1	2
B	1	3
C	4	1
D	3	1

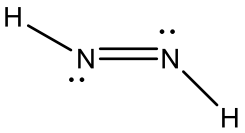
Answer: D

Angle of deflection $\propto \frac{\text{charge of ion}}{\text{mass}}$

Given that alpha particles (α–particles) are similar to the nucleus of He (i.e. $^4He^{2+}$) and beta particles (β–particles) can be considered as electrons ($^0e^-$), α–particles will be deflected towards the negative plate and by a smaller magnitude (due to greater mass no.) than β–particles (towards positive plate).

4 Diazene has a molecular formula of N_2H_2. Given that the nitrogen and hydrogen show their usual valencies, which of the following correctly describes the shape and bond angle around each central atom?

	shape	bond angle
A	bent	110º
B	linear	180º
C	tetrahedral	109º
D	trigonal planar	120º



Concept: Drawing Lewis structure, identify shape and bond angle

Answer: A

Around each N atom, there are 2 bonds pairs and 1 lone pair of electrons. Hence, it is bent around each N atom and the bond angle is between 109º and 120º. Hence, the most appropriate answer is 110º.

5 Which of the following contains delocalised electrons?

1 Graphite
2 Sodium
3 Ethanoate ion
4 Cyclohexene

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

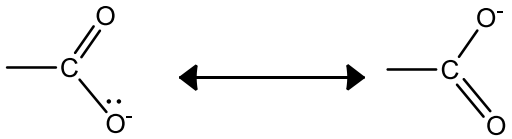
Concept: Structure and bonding, delocalisation of electrons

Answer: C

1: Each C atom is bonded to 3 other C atoms and the remaining electron is delocalised along the layers of carbon atoms.

2: Sodium metal has a giant metallic structure, which has strong electrostatic forces of attraction between the metal ion and the sea of delocalised electrons. The valence electron is involved in delocalisation.

3: The negative charge on oxygen can be delocalised across the sp^2 hybridised carbon.



4: The π electrons are localised between the 2 C in the C=C.

6 Which equation corresponds to the enthalpy change stated?

A	$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$	$\Delta H^{\ominus}_{neutralisation}$
B	$Na_2SO_4(s) + aq \rightarrow 2Na^+(aq) + SO_4^{2-}(aq)$	$\Delta H^{\ominus}_{solution}$
C	$S_8(s) + 8O_2(g) \rightarrow 8SO_2(g)$	$\Delta H^{\ominus}_{formation}$
D	$Br_2(l) \rightarrow 2Br(g)$	$\Delta H^{\ominus}_{atomisation}$

Ans: B
From definitions of various enthalpy changes
Errors in options given:
$\Delta H^{\ominus}_{neutralisation}$ **– only 1 mol of H_2O formed (not 2 mol)**
$\Delta H^{\ominus}_{formation}$ **– only 1 mol of compound formed (not 8 mol)**
$\Delta H^{\ominus}_{atomisation}$ **– breaking of bonds in gaseous phase (not liquid phase)**

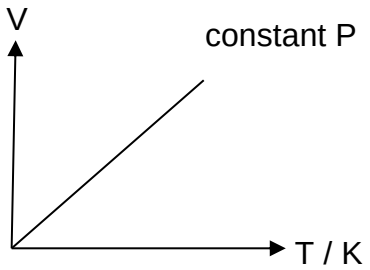
7 In which of the following processes will ΔS be negative?

A Photosynthesis
B Electrolysis of water
C Boiling of water
D Dissociation of solid $MgSO_4$ in water

Ans: A
A: $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ ΔS=-ve
B: $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ OR $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ ΔS=+ve
C: phase change from liquid to solid ΔS=+ve
D: $MgSO_4 + aq \rightarrow MgSO_4(aq)$ ΔS=+ve

8 Which of the following diagrams correctly describes the behaviour of a fixed mass of an ideal gas?
(P = pressure, ρ = density, V = volume, T = temperature).

1

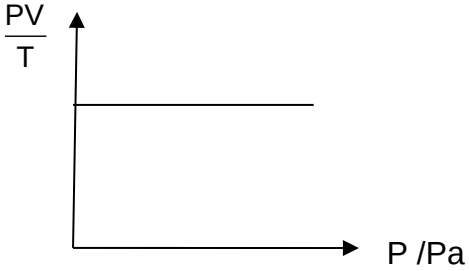


PV = nRT(K)

$V = \frac{nR}{P}T(K)$

V ∝ T(K) (∴ linear line passing through origin)

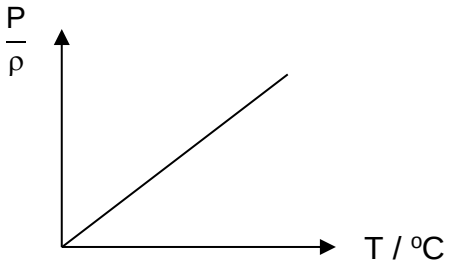
2



PV = nRT

$\frac{PV}{T}$ = nR (constant, ∴ horizontal line)

3



A 1 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

$PV = nRT(K)$

$P = \frac{\rho}{M_r} RT(K)$

$\frac{P}{\rho} = \frac{RT(K)}{M_r}$

$\frac{P}{\rho} = \frac{R(T(^oC)+273)}{M_r}$

$\frac{P}{\rho} = \frac{RT(^oC)}{M_r} + \frac{273R}{M_r}$

Plotting P/ρ vs T(^{o}C) will give a linear line with a y-intercept of $\frac{273R}{M_r}$

9 A sample of HBr gas was decomposed in a sealed container at temperature T. The decomposition equation is given below.

$$2HBr(g) \rightleftharpoons H_2(g) + Br_2(g) \qquad \Delta H \text{ is positive}$$

Which of the following statements is **false**?

A Equal amounts of H_2 and Br_2 are formed at equilibrium.

B When a catalyst is added, the rates of the forward and reverse reactions are increased by the same extent.

C The K_c will decrease if reaction is carried out at higher temperature.

D The equilibrium position is unaffected when the volume of the container is decreased.

Concept: Le Chatelier's Principle, Calculating K_c, mole fraction

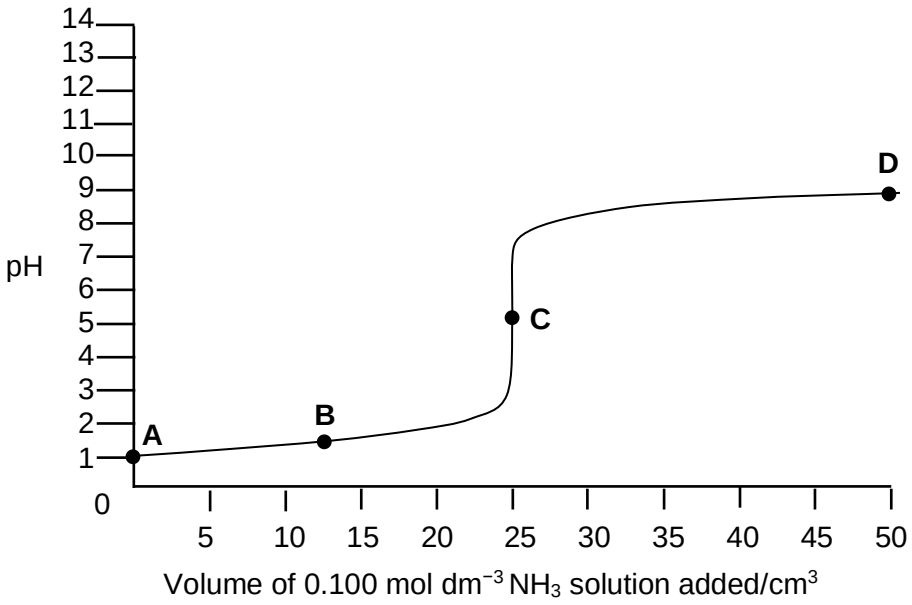
When the temperature is increased, the position of equilibrium shifts to the right to favour the forward reaction which is heat-absorbing/endothermic. K_c will increase.

$2HBr(g) \rightleftharpoons H_2(g) + Br_2(g)$

Since the number of mole of gases on both sides of the equation are the same, there would be no change in equilibrium position when the volume of container is decreased and the pressure is increased. Hence Option D is true.

10 The pH changes when 0.100 mol dm^{-3} $NH_3(aq)$ is added dropwise to 25.0 cm^3 of 0.100 mol dm^{-3} HC*l* as shown below.

At which point on the graph does pOH = pK_b, where K_b is the base dissociation constant of the weak base?



Concept: Chemistry of Aqueous Solutions, interpreting titration curve

Answer: D

For pOH = pK_b, $[NH_4^+] = [NH_3]$
HC*l* + NH_3 → NH_4Cl
At **A**, species present: HC*l*
At **B**, species present: HC*l* and NH_4Cl
At equivalence point **C**, NH_4^+ ion hydrolyses in water, $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$
At **D**,

n_{NH3} = 25.00/1000 x 0.100
= 2.5 x 10^{-3} mol

n_{NH4Cl} formed = 25.0/1000 x 0.100
= 2.5 x 10^{-3} mol

At **D**, $[NH_4^+] = [NH_3]$

11 Ammonia usually reacts as a base. In which reaction does it behave as an acid?

1 $Hg_2Cl_2 + 2NH_3 \rightarrow Hg + HgCl(NH_2) + NH_4^+ + Cl^-$
2 $Cu^{2+}(aq) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4]^{2+}(aq)$
3 $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$

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

Answer: D

Option 1: NH_3 donate a H^+ to form NH_2^-. ➔ Bronsted-Lowry acid

Option 2: The 4 NH_3 donate a pair of electrons each to the Cu^{2+} to form an adduct through the formation of a dative bond. (complex formation – covered in JC2 Transition Metals) ➔ Lewis base

Option 3: Ammonia accepts a H^+ from HCl to form ammonium ion (NH_4^+). ➔ Bronsted-Lowry base

12 The table shows experimental results obtained for the reaction of hydrogen peroxide with acidified iodide ions to liberate iodine.

initial concentrations of reactants / mol dm^{-3}			*initial rate of formation of iodine* / mol dm^{-3} s^{-1}
$[H_2O_2]$	$[I^-]$	$[H^+]$	
0.010	0.010	0.010	2.0×10^{-6}
0.030	0.010	0.010	6.0×10^{-6}
0.030	0.020	0.010	1.2×10^{-5}
0.030	0.020	0.020	1.2×10^{-5}

What can be deduced from these results?

1 The rate equation for the reaction can be written: rate = $k[H_2O_2][I^-]$.
2 The reaction is zero order with respect to acid.
3 The units of rate constant is $mol^{-2}\ dm^6\ s^{-1}$.
4 Both hydrogen peroxide and iodide ions are involved in the rate-determining step.

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

Ans: C

Comparing expt 1 and 2, $[I^-]$ and $[H^+]$ kept constant, when $[H_2O_2]$ is tripled, initial rate is also tripled. ∴ reaction is 1st order w.r.t. H_2O_2.

Comparing expt 2 and 3, $[H_2O_2]$ and $[H^+]$ kept constant, when $[I^-]$ is doubled, initial rate is also doubled. ∴ reaction is 1st order w.r.t. I^-.

Comparing expt 3 and 4, $[H_2O_2]$ and $[I^-]$ kept constant, when $[H^+]$ is doubled, initial rate is unchanged. ∴ reaction is zero order w.r.t. H^+. (statement 2)

Hence, rate equation is rate = $k[H_2O_2][I^-]$ (statement 1) and only H_2O_2 and I^- are involved in the rate-determining step. (statement 4)

From experiment 1,

units of k $= \frac{\text{rate}}{[H_2O_2][I^-]} = \frac{\text{mol dm}^{-1}\ \text{s}^{-1}}{(\text{mol dm}^{-3})^2}$

$= \text{mol}^{-1}\ \text{dm}^3\ \text{s}^{-1}$ (not statement 3)

13 The mechanism for a certain reaction is given below:

$$2P \longrightarrow R \text{ (fast)}$$

$$R + Q \rightleftharpoons S \text{ (slow)}$$

$$S + Q \longrightarrow P_2Q_2 \text{ (fast)}$$

What conclusion can be drawn from the above mechanism?

A The rate equation is rate = $k[P]^2[Q]$.

B The overall order of reaction is 2.

C The units of the rate constant, k, is $\text{mol}^{-1}\ \text{dm}^3\ \text{s}^{-1}$.

D The half-life of [Q] is halved when [Q] is doubled,

Overall equation: $2\mathbf{P} + 2\mathbf{Q} \rightarrow \mathbf{P_2Q_2}$
From here, we can conclude that **R** and **S** are intermediates and should not appear in the rate equation.

The second step of the reaction mechanism, **R** + **Q** $\rightleftharpoons$ **S** is a slow step.
Hence, Rate = k [**R**] [**Q**].

Since R is the intermediate formed from 2 moles of **P**, Rate = k $[\mathbf{P}]^2$ [**Q**]
Thus overall order of reaction is 3.

Rate constant **k** has the units of $\frac{mol dm^{-3} s^{-1}}{(mol dm^{-3})^3} = mol^{-2} dm^6 s^{-1}$

The reaction is first-order with respect to **Q**, hence **Q** has a constant half-life that is independent of [**Q**].

Answer: Option **A**

14 Four elements with atomic numbers from 11 to 17 inclusive have the following properties.

- Chloride of **E** dissolves in water and turns moist blue litmus red.
- Oxide of **F** is amphoteric.
- **G** has the lowest electronegativity among these four elements.
- **H** has the smallest atomic radius.

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

A **F**, **G**, **H**, **E**
B **F**, **G**, **E**, **H**
C **G**, **F**, **E**, **H**
D **G**, **F**, **H**, **E**

Concept: The Periodic Table − properties of Period 3 elements (chlorides and oxides)
Answer: C

$MgCl_2$, $AlCl_3$, $SiCl_4$ and PCl_5 dissolves in water to give acidic solutions and hence turn blue litmus red. E could be Mg, Al, Si or P.

Only Al_2O_3 is amphoteric. F is Al.

Across a Period, the electronegativity increases. G is the first element of give E, F, G and H.

Chlorine has the smallest atomic radius. H is chlorine.

15 *Use of Data Booklet is relevant to this question.*
Which statements about the elements chlorine, bromine and iodine are correct?

1 The oxidising power increases from chlorine to iodine.
2 The strength of the covalent bonds in the molecules decreases from chlorine to iodine.
3 The magnitude of the first electron affinity increases from chlorine to iodine.

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

Concept: The Periodic Table – properties of Group 17
Answer: B

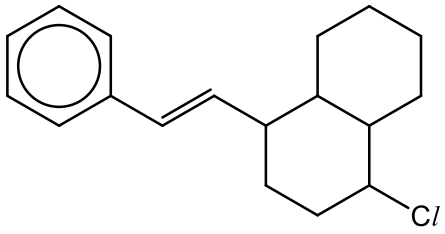
Statement 1: Group 17 elements, X_2, have positive $E^{\ominus}$ values, which indicates that they are oxidising in nature. They tend to be reduced to form X^- ions.
$Cl_2 + 2e \rightleftharpoons 2Cl^-$ $\quad E^{\ominus} = +1.36$ V

$Br_2 + 2e \rightleftharpoons 2Br^-$ $E^\ominus = +1.07$ V
$I_2 + 2e \rightleftharpoons 2I^-$ $E^\ominus = +0.54$ V
$E^\ominus$ values decreases down the group, which indicates the oxidising power of the elements decreases from Cl_2 to I_2. Hence, Statement 1 is wrong.

Statement 2:
C*l*– C*l* BE = 244 kJ mol^{-1}
Br– Br BE = 193 kJ mol^{-1}
I– I BE = 151 kJ mol^{-1}
Down the group, as the size of the halogen atom increases, the X–X bond length increases and is weaker. Hence, Statement 2 is correct.

Statement 3:
First electron affinity is the energy released when one mole of electrons is added to one mole of gaseous atoms to form one mole of gaseous anions. First EA is always negative because it is an exothermic reaction, attraction is formed between nucleus and the incoming electron and hence energy is released.
$X(g) + e \rightleftharpoons X^-(g)$
Down the group, the size of halogen atom increases, the attraction between the nucleus and the incoming electron is weaker. Hence, less energy is released. Magnitude of the first EA decreases from C*l* to I.

16 How many stereoisomers does compound **Q** exhibit?



Compound **Q**

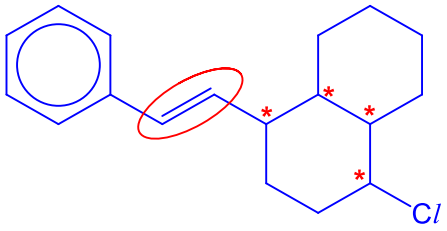
A 2 **B** 5 **C** 16 **D** 32

Concept: Identification of chiral centres and C=C that can exhibit cis/trans;

Answer: D

Total number of stereoisomers = 2^n *(Note: maximum no. of stereoisomers = 2^n, where n = total no. of C=C bonds that can show Cis-trans isomerism + no. of chiral carbon centres)*

Total number of stereoisomers = $2^5 = 32$



17 Which of the following is a **propagation** step in the formation of 1,1-dibromopropane from the reaction between propane and bromine in the presence of ultraviolet light?

A $CH_3CH_2CH_2Br + Br\bullet \rightarrow CH_3CH_2CH_2\bullet + Br_2$
B $CH_3CH_2CH_2\bullet + Br\bullet \rightarrow CH_3CH_2CH_2Br$
C $CH_3CH_2CH_2\bullet + Br_2 \rightarrow CH_3CH_2CHBr\bullet + HBr$
D $CH_3CH_2CHBr\bullet + Br_2 \rightarrow CH_3CH_2CHBr_2 + Br\bullet$

Concept: Alkane, Free Radical Substitution

Answer: D

Propagation (generation of new radicals in each step):

Highly reactive bromine radicals **react with propane molecules** and abstract one **hydrogen atom leaving a propyl radical**

$CH_3CH_2CH_3 + Br\bullet \longrightarrow CH_3CH_2CH_2\bullet + HBr$

Regeneration of bromine free radical by propyl radical

$CH_3CH_2CH_2\bullet + Br_2 \longrightarrow CH_3CH_2CH_2Br + Br\bullet$

Regenerated bromine free radical reacts with 1-bromopropane and process **repeats** with 1-bromopropyl radical

$CH_3CH_2CH_2Br + Br\bullet \longrightarrow CH_3CH_2CHBr\bullet + HBr$

$CH_3CH_2CHBr\bullet + Br_2 \longrightarrow CH_3CH_2CHBr_2 + Br\bullet$

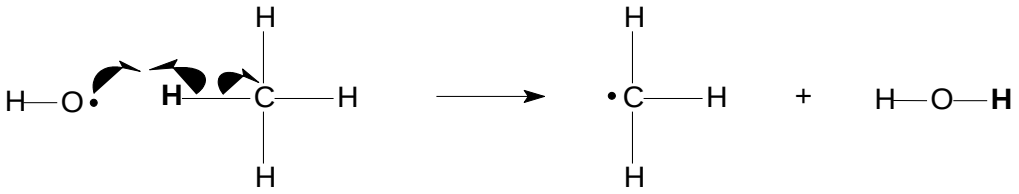
18 Methane is a greenhouse gas but is destroyed in the troposphere by the action of hydroxyl radicals.

$$\bullet OH + CH_4 \rightarrow \bullet CH_3 + H_2O$$

Which statement about this reaction is correct?

A The reaction involves homolytic fission and σ bond formation.
B The reaction involves heterolytic fission and σ bond formation.
C The reaction involves heterolytic fission and π bond formation.
D The total number of electrons in the two reacting species is 20.

Answer: A

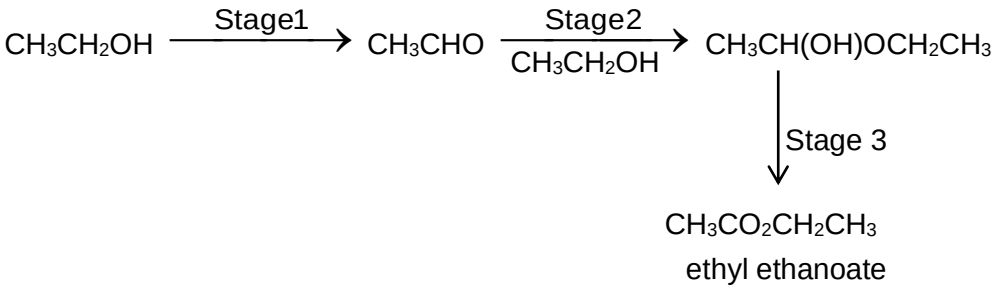


The reaction involves the breaking of a C–H covalent bond in CH_4 with one of the bonded electrons going to each atom, forming two radicals ($\bullet CH_3$ and $\bullet H$) $\Rightarrow$ homolytic fission
The unpaired electron in the hydrogen radical ($\bullet H$) and that in the hydroxyl radical ($\bullet OH$) then pair up to form a σ bond (O–H bond).

(Note: Heterolytic fission is the breaking of a covalent bond with both of the bonded electrons going to one of the atoms, forming a cation and an anion.)

The total number of electrons in the two reacting species is 9($\bullet OH$) + 10(CH_4) = 19. Hence, option D is incorrect.

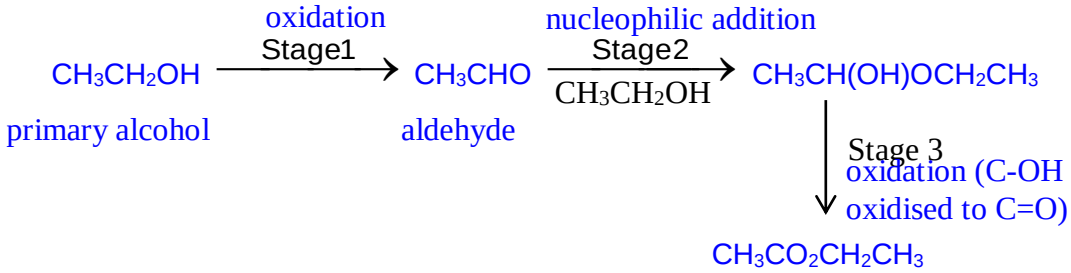
19 A new industrial preparation of ethyl ethanoate has been developed using cheap sources of ethanol.



Which process is involved at some stage in this reaction sequence?

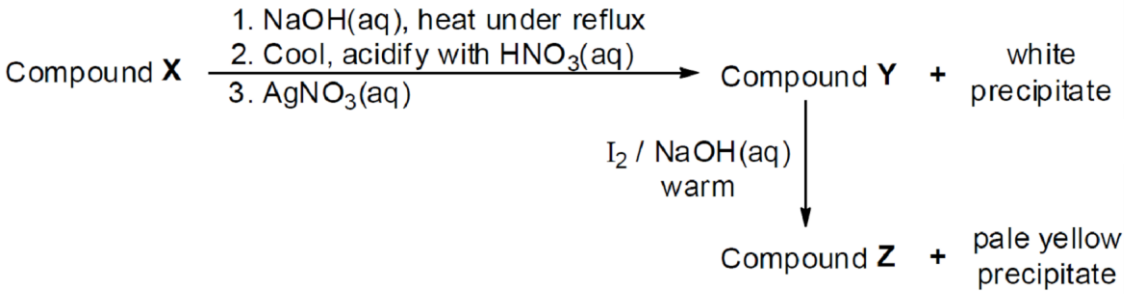
A electrophilic addition
B nucleophilic substitution
C nucleophilic addition
D condensation

Answer: **C**



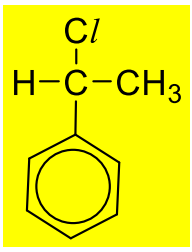
Answer is **C**. Stages 1 and 3 are oxidation whereas stage 2 is nucleophilic addition with CH_3CH_2OH acting as the nucleophile. Stage 2 is not condensation as there is no loss of any molecules.

20 Compound **X** was subjected to the following sequence of reactions.

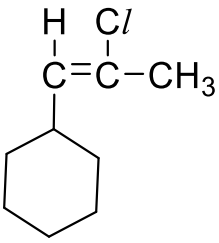


Which of the following could be the structure of **X** ?

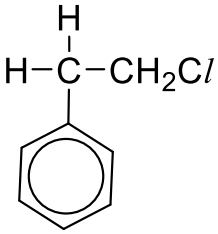
A



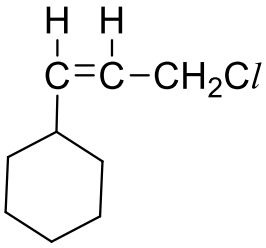
C

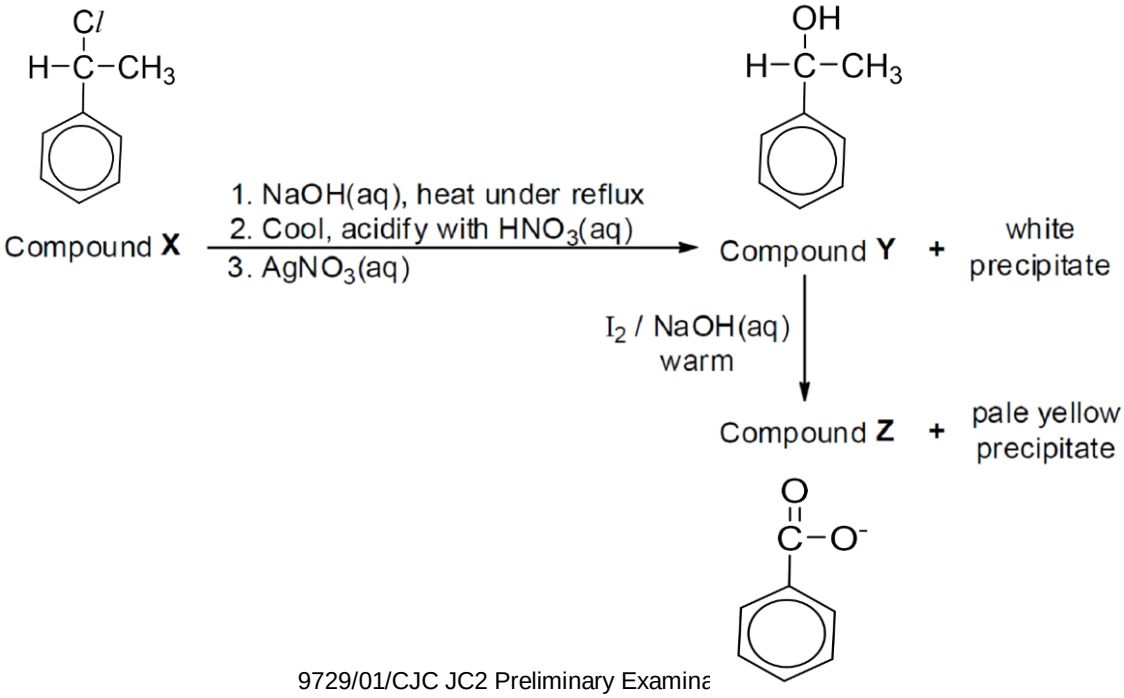


B

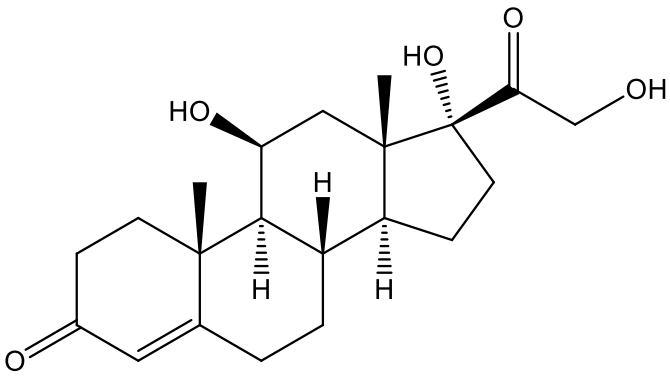


D





21 Hydrocortisone is commonly used as an active ingredient in anti-inflammatory creams and has the following structure.



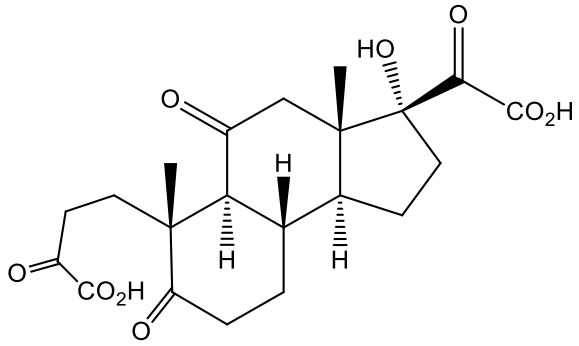
hydrocortisone

Which of the following statements about hydrocortisone is correct?

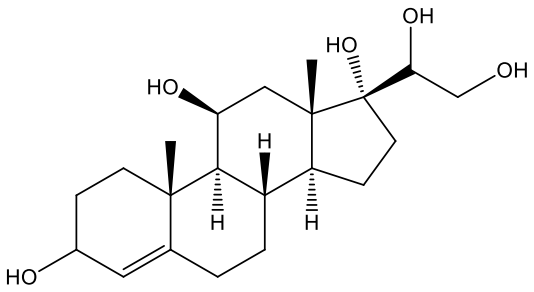
A When treated with an excess of hot acidified $KMnO_4$, it forms a compound containing six carbonyl groups.
B When warmed with aqueous alkaline iodine, a yellow precipitate is observed.
C When treated with cold dilute $KMnO_4$, it forms a compound containing two additional hydroxy groups.
D When treated with $NaBH_4$ in the presence of methanol, it forms a compound containing seven hydroxy groups.

Concept: Organic reactions involving oxidation and reduction

A The C=C, primary and secondary alcohols will undergo oxidation with hot acidified $KMnO_4$ to give the following compound. Only 4 carbonyl groups are formed.



B The compound does not contain $–CH_3CH(OH)$ or $–COCH_3$, hence no yellow precipitate is observed.
C When reacted with cold dilute $KMnO_4$, mild oxidation of the C=C occurs and a diol (2 alcoholic –OH groups) is formed.
D When treated with $NaBH_4$, the following compound is obtained (5 hydroxy groups are present). Note that C=C does not react with $NaBH_4$.



22 Compound **P**, $C_4H_8O_2$, has an unbranched carbon chain. An aqueous solution of **P** has an approximate pH of 3. Compound **Q**, C_3H_8O, is a secondary alcohol.

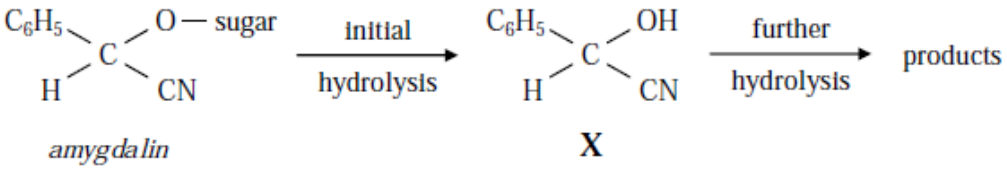
P and **Q** are reacted together in the presence of a small amount of concentrated sulfuric acid to form **R** as the major organic product.

What is the structural formula of **R**?

A $(CH_3)_2CHCO_2CH_2CH_2CH_3$
B $CH_3(CH_2)_2CO_2CH(CH_3)_2$
C $CH_3(CH_2)_2CO_2(CH_2)_2CH_3$
D $(CH_3)_2CHCO_2CH(CH_3)_2$

Ans: B
- **P is butanoic acid, $CH_3(CH_2)_2CO_2H$, which forms an ester with Q (2° alcohol).**
- **ester formed contains butanoate group (∴ either B or C).**
- **since Q is a 2° alcohol, ester formed is not C.**

23 *Amygdalin* is partly responsible for the flavour of almonds. On hydrolysis, it first gives compound **X**, which is then further hydrolysed to give other products.



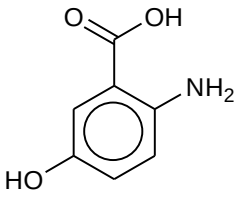
amygdalin **X**

What are the other products formed after further hydrolysis?

A $C_6H_5CH(OH)CO_2H$ and NH_3
B $C_6H_5CH_2OH$ and CO_2 and NH_3
C $C_6H_5CO_2H$ and HCHO and NH_3
D C_6H_5OH and CH_3CN

Ans: A
- **The –CN group is hydrolysed to give the corresponding carboxylic acid and NH_3.**

24 5-hydroxyanthranillic acid (5-HAA) is a tryptophan metabolite that is suspected of generating oxidative stress and neuronal death.

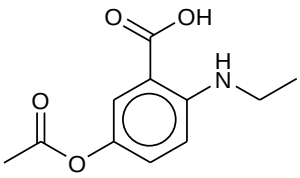


5-HAA

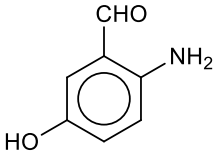
When 5-HAA was reacted with ethanoyl chloride followed by lithium aluminium hydride, Li*Al*H$_4$, in dry ether, the product was found to give a purple colouration with neutral Fe*Cl*$_3$(aq).

Which is a likely product?

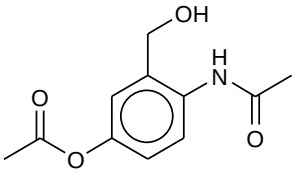
A



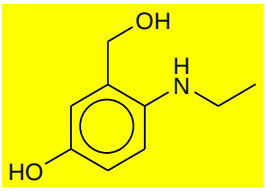
B



C

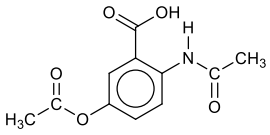


D



Concept: Condensation reactions with amines, phenols, distinguishing test for phenols

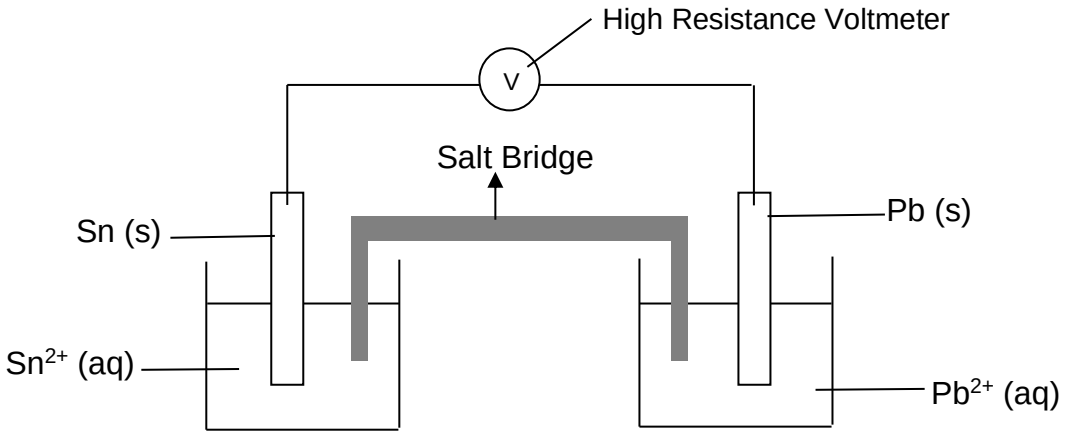
D Ethanoyl chloride undergoes condensation reaction with amines, alcohols and phenols. The intermediate produced contains an amide and an ester.



Lithium aluminium hydride can reduce carboxylic acid (to 1^o alcohol), amide (to the corresponding amine) and ester (to the corresponding alcohols or phenol).

Since purple colouration with neutral Fe*Cl*$_3$ (aq) is observed, this indicates that the phenol is formed from the reduction of esters.

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



A student set up an electrochemical cell as above and made the conclusion listed below. Which of the statements are correct?

1 The reaction is feasible and Pb electrode grows larger with time.
2 Electrons flow from the Sn electrode to the Pb electrode.
3 Sn is the positive electrode while Pb is the negative electrode.
4 Concentrated KC*l* is suitable to be used as salt bridge.

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

Answer: A

Concept: Electrochemical cell setup, predicting feasibility based on $E^{\ominus}_{cell}$
Answer: A (i and ii only)

$Pb^{2+} + 2e \rightleftharpoons Pb$ -0.13 V $E^{\ominus}_{red}$

$Sn^{2+} + 2e \rightleftharpoons Sn$ -0.14 V $E^{\ominus}_{oxd}$

$E^{\ominus}_{cell}$ = -0.13 – (-0.14) = + 0.01

(reaction is feasible and Pb is formed)

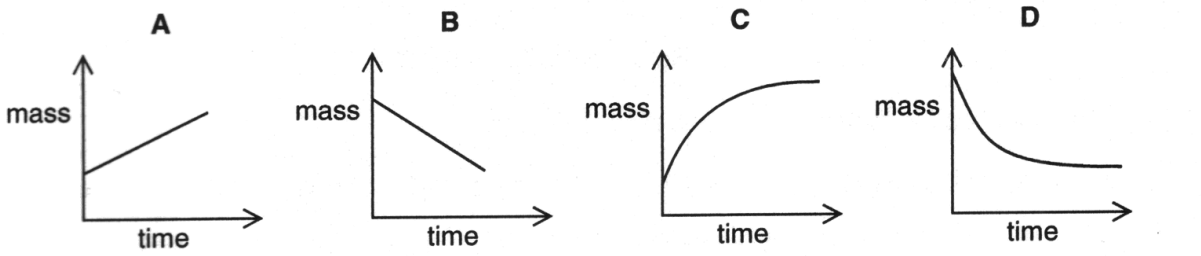
Reduction: $Pb^{2+} + 2e \rightarrow Pb$ ……..Pb is the cathode (+)

Oxidation: $Sn \rightarrow Sn^{2+} + 2e$ ……..Sn is the anode (-)

Electrons flow from anode to cathode i.e. from Sn to Pb electrode.

KC*l* is unsuitable to be used as salt bridge as $PbCl_2$ will be precipitated instead.

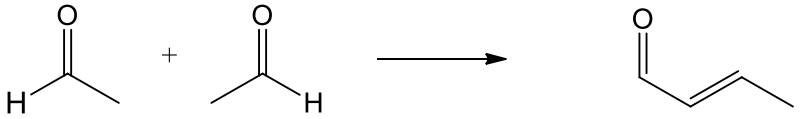
26 Electrolysis of aqueous copper(II) sulfate was carried out using copper electrodes and a steady current. Which graph shows the change in mass of the cathode with time?



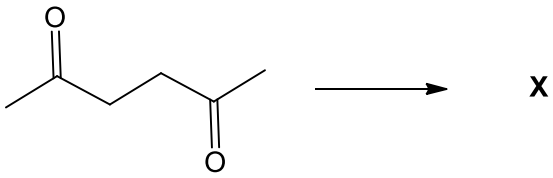
Concept: Electrolysis, mass of substance liberated during electrolysis
Answer: A

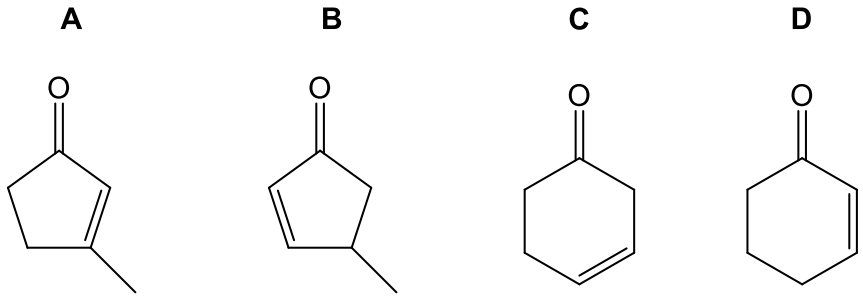
Reduction occurs at the cathode
$Cu^{2+} + 2e^- \rightarrow Cu$ (cathode mass increases)
Since mass α Q (Faraday's 1st Law Electrolysis)
And Q = I t
Therefore, mass α time

27 Aldol condensation is used in the manufacture of pharmaceuticals. One example of such a reaction is as shown below in the presence of a base.



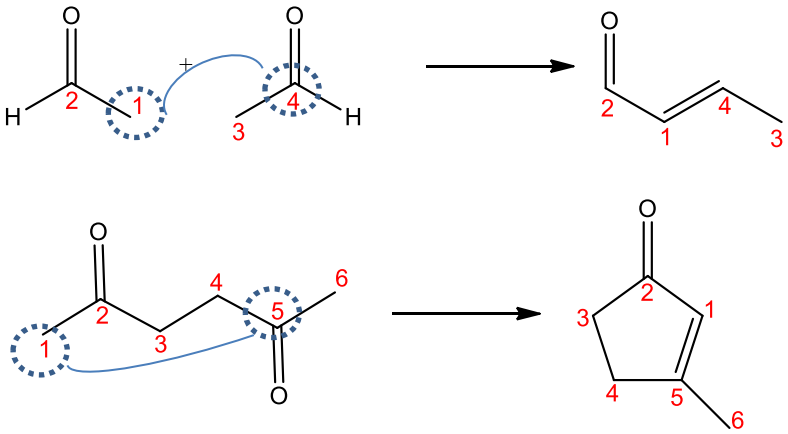
Under similar conditions, what would be the product **X**?



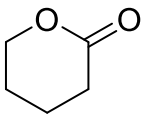


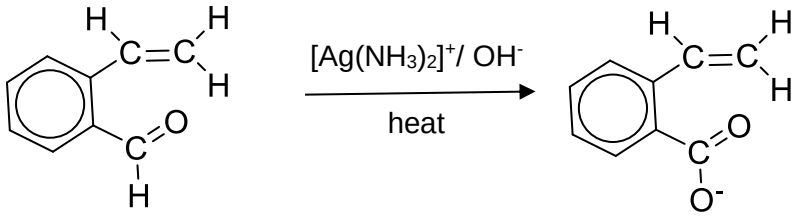
Concept: Pattern recognition of novel reaction; predicting structure of product

Answer: A



28 Which of the following reactions would yield the product shown?

1 $HO(CH_2)_4COOH \xrightarrow[\text{heat}]{\text{conc. } H_2SO_4}$ 

2 

3 $CH_3CH_2CH_2OH \xrightarrow[\text{heat}]{\text{NaBr(aq)}} CH_3CH_2CH_2Br$

A 1 only

B 2 only

C 1 and 2 only

D 1, 2 and 3 only

Option 1 is correct:
The alcohol and the carboxylic acid functional groups of $HO(CH_2)_4COOH$ undergo condensation reaction to cyclic ester molecule.

Option 2 is correct:
The aromatic aldehyde undergoes mild oxidation with alkaline $[Ag(NH_3)_2]^+$ (Tollen's reagent) to form a carboxylate ion.

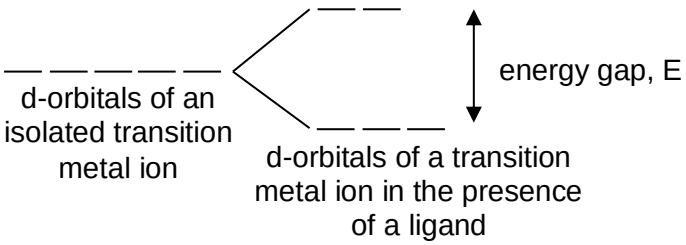
Option 3 is incorrect:
Solid NaBr is needed to react with **conc H_2SO_4** while **heating under reflux** to produce hydrogen bromide, HBr.

$$NaBr(s) + \text{conc. } H_2SO_4 \rightarrow \mathbf{HBr(g)} + NaHSO_4$$

HBr undergoes nucleophilic substitution reaction with $CH_3CH_2CH_2OH$ to form $CH_3CH_2CH_2Br$

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

The following diagram shows how the d–orbitals are split in an octahedral environment.



Some transition metal ions exhibit the ability to change their electronic configuration from a 'high spin' state to a 'low spin' state.

In a 'high spin' state, the electrons occupy all the d–orbitals singly first, before starting to pair up in the lower energy d–orbitals.

In a 'low spin' state, the lower energy d–orbitals are first filled, by pairing up if necessary, before the higher energy d–orbitals are used.

Which one of the following transition metal ions is likely to be able to exhibit both spin states?

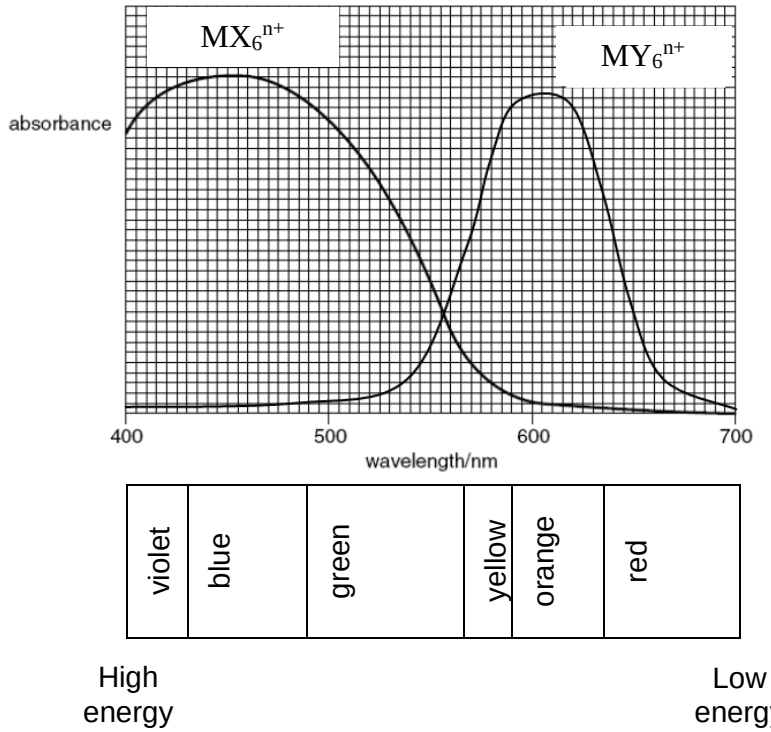
1 Fe^{3+}
2 Cu^{2+}
3 Cr^{3+}
4 Co^{3+}

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

Answer: B

Fe^{3+}: [Ar] $3d^5$--The high spin and low spin configuration are different. Hence it can show a difference between the two spin states.
Cu^{2+}: [Ar] $3d^9$ -- The high spin and low spin configuration are exactly the same. Hence it cannot show a difference between the two spin states.
Cr^{3+}: [Ar] $3d^3$ --The high spin and low spin configuration are exactly the same. Hence it cannot show a difference between the two spin states.
$Co^{3+:}$ [Ar] $3d^6$ -- The high spin and low spin configuration are different. Hence it can show a difference between the two spin states.

30 The absorbance graph below shows the visible spectra of two complexes of transition metal M, MX_6^{n+} and MY_6^{n+}.



What is the colour of each complex and which ligand causes a larger d-orbital splitting?

	Colour of MX_6^{n+}	Colour of MY_6^{n+}	ligand which causes a larger d-orbital splitting
A	Violet	Orange-red	X
B	Red	Green-blue	X
C	Violet	Orange-red	Y
D	Red	Green-blue	Y

Answer: B
For MX_6^{n+}, it absorbs wavelength at the 400-600 nm region, thus the colour observed will be red.
For MY_6^{n+}, it absorbs wavelength at the 550-650 nm region, thus the colour observed will be green-blue.
Shorter wavelength absorbed means a larger ΔE → Thus, X causes a larger d-orbital splitting.