

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct and shade your choice on the answer sheet provided.

- 1** For indoor air quality safety standards, the maximum safe tolerance level of carbon monoxide gas is $6 \times 10^{-4} \text{ m}^3$ of carbon monoxide in 1 m^3 of air. Given that a typical room measures 4 m by 4 m by 3 m, calculate the number of molecules of carbon monoxide present in the room at this tolerance level at room temperature and pressure?

- A** 1.13×10^{24}
B 7.22×10^{23}
C 1.51×10^{22}
D 7.22×10^{20}

- 2** Soluble mercury compounds such as mercury(II) nitrate are highly toxic. One removal method involves the treatment of wastewater contaminated with mercury(II) nitrate with sodium sulfide to produce solid mercury(II) sulfide and sodium nitrate solutions.

Calculate the mass of mercury(II) sulfide formed when 0.020 dm^3 of $0.100 \text{ mol dm}^{-3}$ sodium sulfide reacts with 0.050 dm^3 of $0.010 \text{ mol dm}^{-3}$ mercury(II) nitrate?

- A** 0.117 g **B** 0.133 g **C** 0.280 g **D** 0.466 g

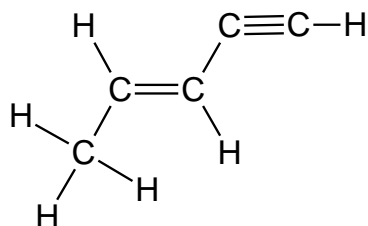
- 3** Gaseous particle **X** has a proton number n , and a charge of +1.
Gaseous particle **Y** has a proton number $(n+1)$, and is isoelectronic with **X**.

Which statement about **X** and **Y** is correct?

- A** When placed in an electric field, the angle of deflection for **X** is the same as that of **Y**.
B **X** requires more energy than **Y** when a further electron is removed from each particle.
C **X** releases more energy than **Y** when an electron is added to particle.
D **X** has a larger radius than **Y**.

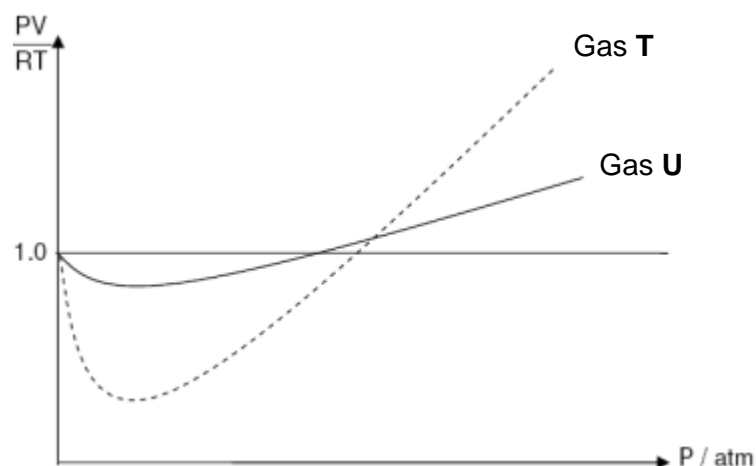
- 4 Covalent bonds are formed by orbital overlap. The shape of unsaturated hydrocarbon molecules can be explained in terms of hybridisation of orbitals.

Which bond is not present in the molecule shown below?



- A σ bond formed by $2sp^3 - 2sp^2$ overlap.
- B σ bond formed by $2sp^3 - 2sp$ overlap.
- C σ bond formed by $1s - 2sp$ overlap.
- D π bond formed by $2p - 2p$ overlap.
- 5 Which statement about graphite is **not** correct?
- A The carbon-carbon bonds in graphite are shorter than those in diamond.
- B It can act as a good lubricant due to the weak forces of attraction between the layers of atoms.
- C Carbon to carbon distances between the planes of hexagonal rings are smaller than those within the planes.
- D It acts as a good conductor of electricity in the direction parallel to the planes containing hexagonal rings of carbon.

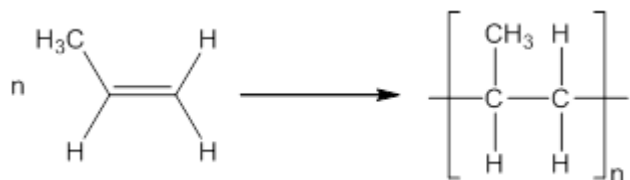
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Which of the following could be the identities of the gases?

	Gas T	Gas U
A	$\text{H}_2(\text{g})$ at 298 K	$\text{CO}_2(\text{g})$ at 298 K
B	$\text{CH}_4(\text{g})$ at 298 K	$\text{NH}_3(\text{g})$ at 298 K
C	$\text{O}_2(\text{g})$ at 500 K	$\text{O}_2(\text{g})$ at 298 K
D	$\text{N}_2(\text{g})$ at 298 K	$\text{N}_2(\text{g})$ at 500 K

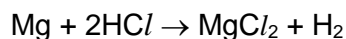
7 The polymerisation of propene to form polypropene occurs readily at room temperatures.



What will be the signs of ΔG , ΔH and ΔS for the polymerisation reaction at room temperature?

	ΔG	ΔH	ΔS
A	+	−	−
B	+	+	−
C	−	+	−
D	−	−	−

- 8 The rate of the redox reaction between hydrochloric acid and Mg



can be followed by measuring the time taken for the same volume of hydrogen to be produced from a range of hydrochloric acid concentrations.

To find the order with respect to hydrochloric acid, which would be the most suitable graph to plot using the data?

- A [HCl] against time
- B [HCl] against $\frac{1}{\text{time}}$
- C Volume H_2 against time
- D Volume H_2 against $\frac{1}{\text{time}}$
- 9 The numerical value of the solubility product of nickel(II) carbonate is 6.6×10^{-9} while that of silver carbonate is 2.1×10^{-11} at 25°C .

Which of the following statements is true?

- A Addition of silver nitrate increases the solubility of silver carbonate.
- B The solubility of silver carbonate is higher than the solubility of nickel(II) carbonate.
- C Addition of nitric acid to a solution containing nickel(II) carbonate increases the solubility product of nickel(II) carbonate.
- D Nickel(II) carbonate precipitates first when sodium carbonate is added to a solution containing equal concentrations of nickel(II) and silver ions.
- 10 What is the pH of 10 cm^3 of 0.05 mol dm^{-3} sodium benzoate?

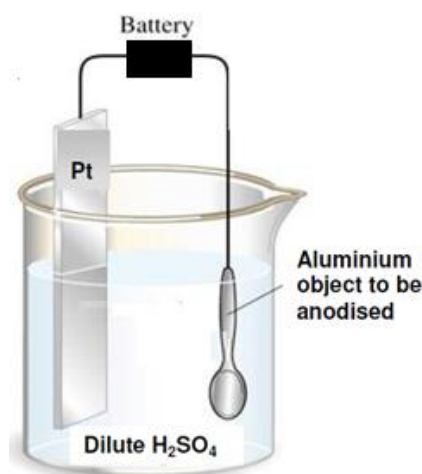
[K_a of benzoic acid = $6 \times 10^{-5}\text{ mol dm}^{-3}$]

- A 6.46
- B 7.46
- C 8.46
- D 9.46

- 11 A sample of 20.0 cm^3 of 0.20 mol dm^{-3} iron(II) sulfate is titrated against 0.05 mol dm^{-3} potassium manganate(VII) in the presence of excess fluoride ions. It is found that 20.0 cm^3 of the manganate(VII) solution is required to reach the end-point.

What is the oxidation number of manganese at end-point?

- A +3
B +4
C +5
D +6
- 12 Anodisation is a process to increase corrosion resistance and surface hardness in aluminium objects.
A possible set up for the process is shown as below:



- Which of the following statements about the anodisation of aluminium is true?
- A Aluminium dissolves at the anode.
B Hydrogen gas is liberated at the anode.
C Water is oxidised at the anode to form oxygen gas.
D Replacing the electrolyte with NaOH(aq) will cause the reaction to cease.
- 13 Which of the following elements forms an oxide with a giant structure and a chloride which is readily hydrolysed?
- A Silicon
B Barium
C Sodium
D Phosphorus

14 An element in Period 3 has the following properties:

- Its first ionisation energy is larger than both the elements before and after it across the period.
- It conducts electricity.
- It reacts slowly with cold water but react readily with steam to give a gas.

Which statement about this element is **not** correct?

- A** It has a high melting and boiling point.
- B** It forms an oxide that produces a solution that is acidic when added to water.
- C** It forms a chloride that produces a solution that is slightly acidic when added to water.
- D** Its oxidation state in compounds usually follows the group number it belongs to in the Periodic Table.

15 The following report appeared in a newspaper article.

Drums of bromine broke open after a vehicle crash on the motorway. Traffic was diverted as purple gaseous bromine drifted over the road (it is denser than air), causing irritation to drivers' eyes. Firemen sprayed water over the scene of the accident, dissolving the bromine and washing it away.

What is wrong with the report?

- A** Bromine does not dissolve in water.
- B** Bromine does not vapourise readily.
- C** Bromine is less dense than air.
- D** Bromine is not purple.

16 When crystalline potassium chromate(VI) was dissolved in water, a yellow solution **Q** was formed. Addition of dilute sulfuric acid to **Q** gave an orange solution **R**. When hydrogen sulfide was bubbled through solution **R**, there was a color change in the solution and yellow sulfur was produced.

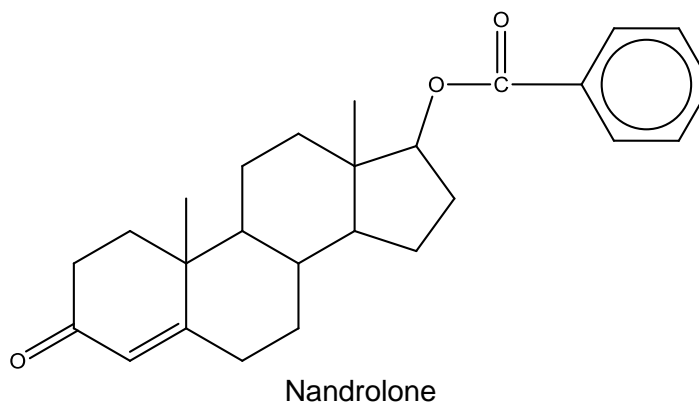
Which process **did not** occur in the above experiment?

- A** Ligand exchange
- B** Redox reaction
- C** Precipitation
- D** Acid-base

- 17 Chlorine compounds show oxidation states ranging from -1 to $+7$.

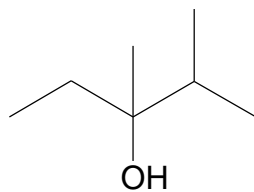
What are the reagents and conditions necessary for the oxidation of chlorine gas into a compound containing chlorine in the $+5$ oxidation state?

- A Cold dilute NaOH
 B Hot concentrated NaOH
 C Concentrated H_2SO_4 at room temperature
 D $\text{AgNO}_3(\text{aq})$ followed by $\text{NH}_3(\text{aq})$ at room temperature
- 18 Which statement correctly **defines** a transition element?
- A Transition elements form many coloured compounds.
 B Transition elements or their compounds are widely used as catalysts.
 C Transition elements form one or more stable ions with partially filled d-orbitals.
 D Transition elements exhibit more than one oxidation state in their compounds.
- 19 How many stereoisomers does a molecule of Nandrolone has?



- A 8 B 16 C 32 D 64

- 20 The structure of compound **Z** is as seen below:

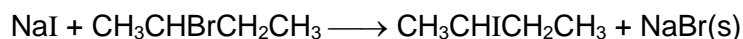


Compound **Z**

It is completely reacted with hot concentrated H_2SO_4 to form compound **Y**. What is the total number of isomers of **Y**?

- A** 2 **B** 3 **C** 4 **D** 5
- 21 2-methylpropanoic acid can be synthesised from 1-chloropropane through a series of reactions.
- Which set of reagents, used in sequential order, would be the most suitable for this synthesis?
- A** PCl_5 , acidified KMnO_4
- B** ethanolic KCN , dilute HCl
- C** aqueous KOH , HCl , ethanolic KCN , dilute HCl
- D** ethanolic KOH , HBr , ethanolic KCN , dilute H_2SO_4
- 22 Which statement about ethanal and propanone is **not** correct?
- A** Both give a positive tri-iodomethane test.
- B** Both react with 2,4-dinitrophenylhydrazine reagent.
- C** Both may be prepared by the oxidation of an alcohol.
- D** Both react with hot acidified sodium dichromate(VI).

- 23** When sodium iodide in propanone is added to an optically active sample of 2-bromobutane, a sodium bromide precipitate is formed after 13 minutes upon heating.

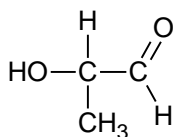


The experiment was repeated several times and the rate equation was found to be

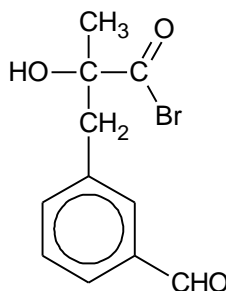
$$\text{Rate} = k[\text{CH}_3\text{CHBrCH}_2\text{CH}_3][\text{NaI}]$$

Which of the following statements is **not** correct?

- A** The mechanism involves a reactive intermediate.
 - B** The organic product sample obtained rotates the plane of polarised light.
 - C** A similar experiment, using 1-bromobutane, will produce a precipitate in less than 13 minutes.
 - D** A similar experiment, using 2-chlorobutane, will take more than 13 minutes to produce a precipitate.
- 24** Which reagent can be used to distinguish between compounds **R** and **S** under suitable conditions?



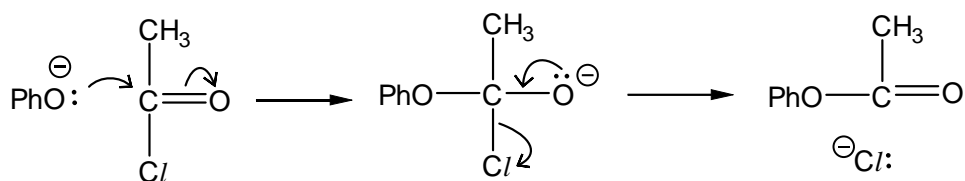
R



S

- A** Acidified potassium dichromate (VI)
- B** Alkaline copper(II) solution
- C** Sodium metal
- D** Phosphorus pentachloride

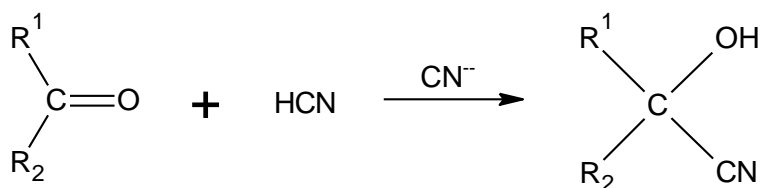
- 25 The two-stage reaction sequence given shows a possible mechanism for the reaction between phenoxide ion and ethanoyl chloride.



where Ph = phenyl

How should the *overall* reaction be classified?

- A Electrophilic addition
 - B Nucleophilic addition
 - C Electrophilic substitution
 - D Nucleophilic substitution
- 26 Cyanohydrins can be made from carbonyl compounds by generating CN^- ions from HCN in the presence of a weak base.

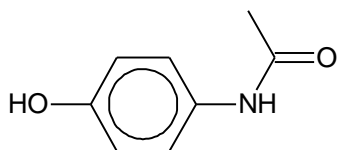


In a similar reaction, $^-\text{CH}_2\text{COOCH}_3$ ions are generated from $\text{CH}_3\text{COOCH}_3$ by strong bases.

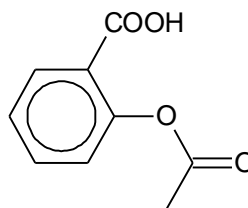
Which compound can be made from an aldehyde and $\text{CH}_3\text{COOCH}_3$?

- A $\text{CH}_3\text{CH}(\text{OH})\text{COOCH}_3$
- B $\text{CH}_3\text{COOCH}_2\text{CH}(\text{OH})\text{CH}_3$
- C $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{COOCH}_3$
- D $(\text{CH}_3)_2\text{C}(\text{OH})\text{CH}_2\text{COOCH}_3$

- 27 Two common drugs administered when a patient experiences headache or fever are paracetamol and aspirin.

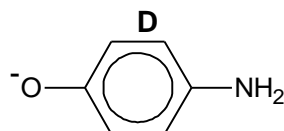
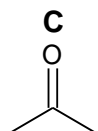
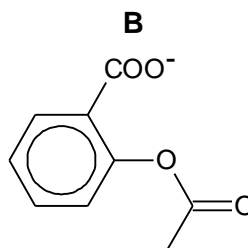
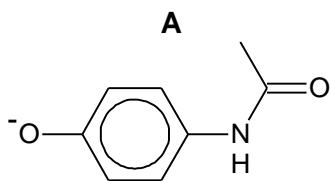


paracetamol

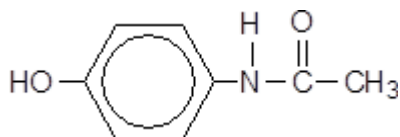


aspirin

A solution of the two drugs was hydrolysed using hot aqueous sodium hydroxide. Which organic product would be produced?



- 28 Acetaminophen is a drug used in headache remedies. It has the following structure:

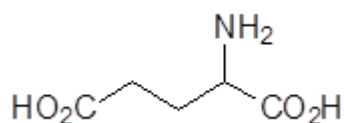


Acetaminophen

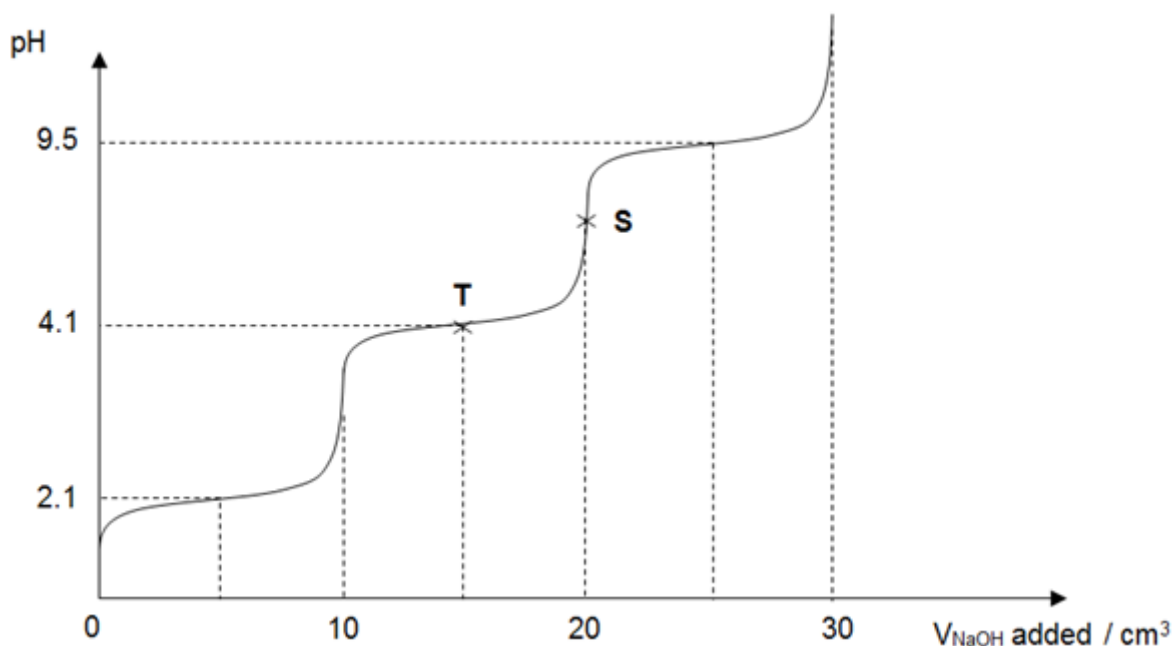
Which of the following reagents reacts with Acetaminophen?

- A** Sodium carbonate
- B** Cold sodium hydroxide
- C** Alkaline aqueous iodine
- D** 2,4-dinitrophenylhydrazine

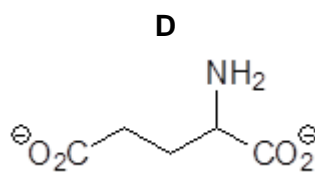
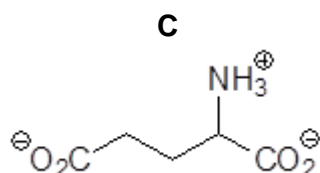
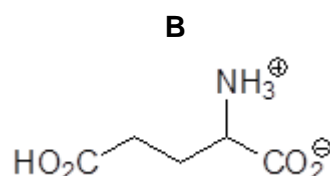
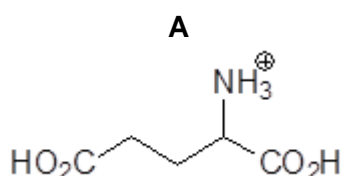
- 29 Which sequence shows the correct order of increasing pK_b in an aqueous solution of equal concentration?
- A $C_2H_5CONH_2 < C_6H_5NH_2 < C_2H_5NH_2 < C_2H_5NH_3^+$
- B $C_2H_5NH_2 < C_6H_5NH_2 < C_2H_5NH_3^+ < C_2H_5CONH_2$
- C $C_2H_5NH_2 < C_6H_5NH_2 < C_2H_5CONH_2 < C_2H_5NH_3^+$
- D $C_2H_5NH_3^+ < C_2H_5CONH_2 < C_2H_5NH_2 < C_6H_5NH_2$
- 30 There are three pK_a values associated with glutamic acid: 2.1, 4.1 and 9.5.



The pH-volume curve obtained when 30 cm³ of NaOH is added to 10 cm³ of the protonated form of glutamic acid of the same concentration is given below.



Which of the following is the major species present at point **S**?



Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to pick a tick against the statements that you consider to be correct).

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

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

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

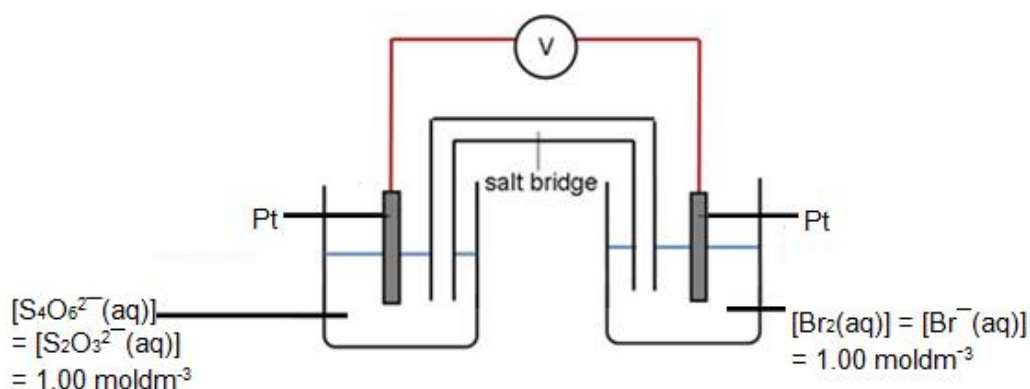
- 31** The radius and charge of each of the six ions are shown below.

ion	J ⁺	L ⁺	M ²⁺	X ⁻	Y ⁻	Z ²⁻
radius / nm	0.14	0.18	0.15	0.14	0.18	0.15

The ionic solids JX, LY and MZ are of the same lattice type. Which of the following statements are correct?

- The melting point increases in the order LY < JX < MZ.
- The numerical value of hydration energy of X⁻ is smaller than that of Z²⁻.
- The solution containing M²⁺ ions is more acidic than the solution containing J⁺ ions.

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



Which of the following will increase the cell potential?

- Adding iodine crystals into the anodic half cell.
- Adding solid silver nitrate into the cathodic half cell.
- Increasing the concentration of Br₂(aq) in the Br₂(aq)/Br⁻(aq) half cell.

- 33** From the position of the elements present in the Periodic Table and the physical properties of the compounds, which compounds are covalent?

- | | | |
|----------|--------------------------------|--------------------------|
| 1 | $(\text{CH}_3)_2\text{SiCl}_2$ | b.p. 70°C |
| 2 | GeCl_4 | b.p. 86°C |
| 3 | AlBr_3 | b.p. 265°C |

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

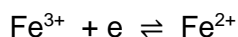
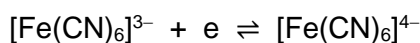
The oxides of titanium, iron and nickel are used as catalysts in the industries.

Which properties are titanium, iron and nickel likely to have in common?

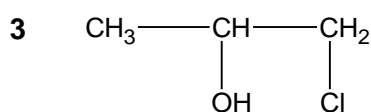
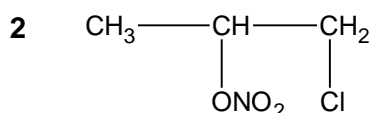
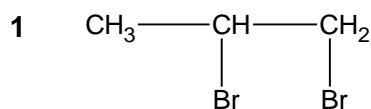
- 1** similar ionic radii
- 2** high melting points
- 3** variable oxidation states

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

With reference to the two half equations below, which statements are correct?



- 1** $[\text{Fe}(\text{CN})_6]^{3-}$ is more stable than Fe^{3+}
 - 2** $[\text{Fe}(\text{CN})_6]^{4-}$ is a stronger reducing agent than Fe^{2+}
 - 3** Both $[\text{Fe}(\text{CN})_6]^{3-}$ and Fe^{3+} can oxidize MnO_4^{2-} to MnO_4^-
- 36** Propene is found to react with chlorine in the presence of aqueous sodium bromide and sodium nitrate. Which of the following are not possible products of the reaction?

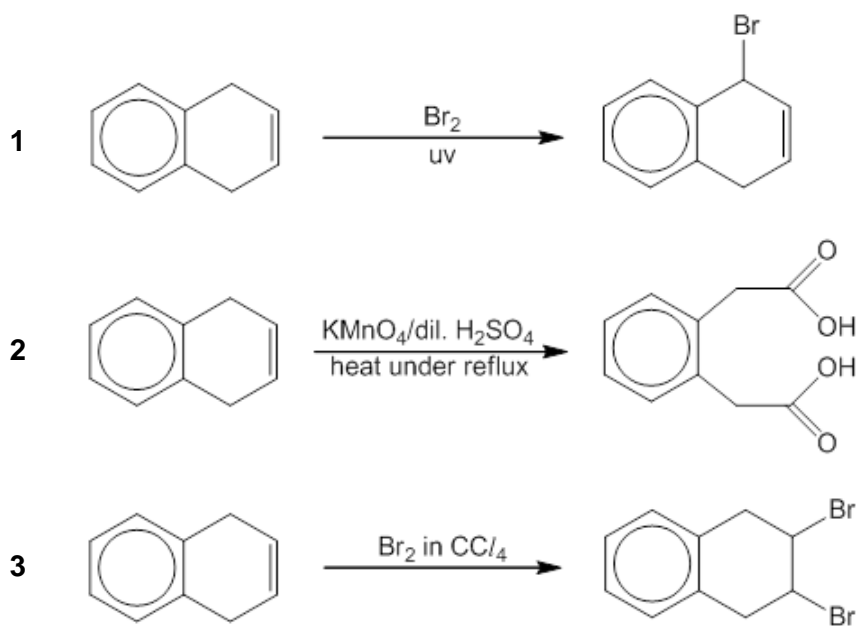


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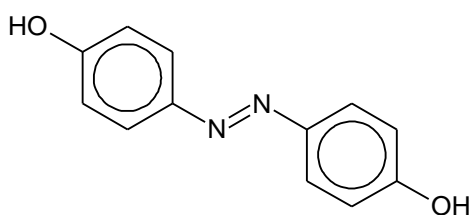
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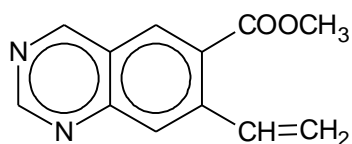
37 Which of the following reactions will not give a good yield of the desired product?



38 The three compounds **E**, **F** and **G** have the following structures?



E



F

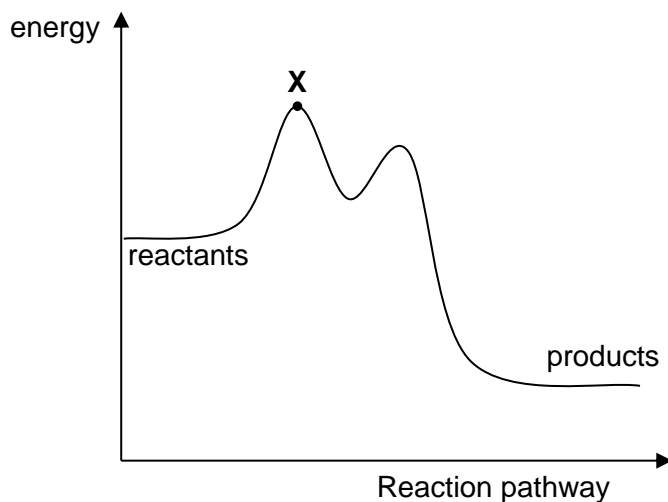
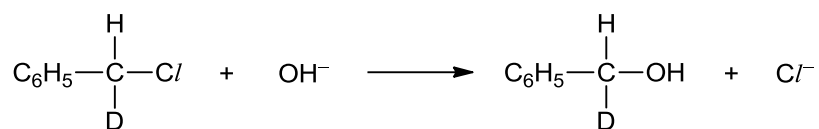


G

Which statements about **E**, **F** and **G** are correct?

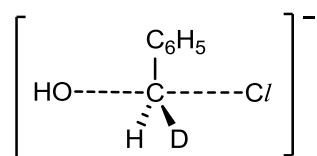
- 1** **E** and **G** have the same empirical formula.
- 2** **E** and **F** are isomers
- 3** The Mr of **F** is exactly twice that of **G**

- 39 The energy profile for the following reaction is shown below. [D = ^2H]



Which conclusions can be drawn?

- 1 The product has no effect on the rotation of plane polarised light.
- 2 The rate of reaction can be increased by increasing concentration of OH^- .
- 3 The structure of the transition state at point X is



- 40 Which groups within an amino acid are able to form a cross-chain link to stabilise the tertiary structure of a protein?

- 1 $-\text{CH}_2\text{CONH}_2$
- 2 $-\text{CH}_2\text{CH}_2\text{CH}_2\text{NHC}(\text{NH}_2)=\text{NH}$
- 3

~ END OF PAPER ~