

**Section A: Fast.**

1. The number of subatomic particles in a  $^{41}\text{K}^+$  ion is

- ☐ 19 electrons, 19 protons, 20 neutrons
- ☐ 18 electrons, 20 protons, 21 neutrons
- ☐ 18 electrons, 19 protons, 22 neutrons
- ☐ 19 electrons, 18 electrons, 23 neutrons

[AQA A-level chemistry]

2. The electron configuration of  $\text{Cu}^{2+}$  is

- ☐  $[\text{Ar}] 3\text{d}^9$
- ☐  $[\text{Ar}] 3\text{d}^{10} 4\text{s}^1$
- ☐  $[\text{Ar}] 3\text{d}^9 4\text{s}^2$
- ☐  $[\text{Ar}] 3\text{d}^{10}$

[AQA A-level chemistry]

3. How many protons are there in 6.0 g of nitrogen gas?

(Avogadro constant:  $L = 6.022 \times 10^{23} \text{ mol}^{-1}$ )

- ☐  $1.3 \times 10^{23}$
- ☐  $9.0 \times 10^{23}$
- ☐  $3.6 \times 10^{24}$
- ☐  $1.8 \times 10^{24}$

[AQA A-level chemistry]

4. A solution of lead(II) chloride ( $M_r = 278.2$ ) contains 1.08 g of  $\text{PbCl}_2$  in  $100 \text{ cm}^3$  of solution. In this solution, the lead(II) chloride is fully dissociated into ions.

The concentration of chloride ions in this solution is

- ☐  $3.88 \times 10^{-3} \text{ mol dm}^{-3}$
- ☐  $7.76 \times 10^{-3} \text{ mol dm}^{-3}$
- ☐  $3.88 \times 10^{-2} \text{ mol dm}^{-3}$
- ☐  $7.76 \times 10^{-2} \text{ mol dm}^{-3}$

[AQA A-level chemistry]

5. Which of these compounds has the highest boiling point?

- ☐ butanal
- ☐ butan-2-ol
- ☐ *E*-but-2-ene
- ☐ 1-fluorobutane

[AQA A-level chemistry]

6. Which of these has permanent dipole-dipole attractions between molecules?

- ☐  $\text{CCl}_4$
- ☐  $\text{C}_2\text{F}_4$
- ☐  $(\text{CH}_3)_2\text{CO}$
- ☐  $\text{CO}_2$

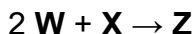
[AQA A-level chemistry]

7. In which one of the following reactions is the standard enthalpy change equal to the standard enthalpy of formation of lithium fluoride?

- ☐  $\text{Li (g)} + \text{F (g)} \rightarrow \text{LiF (s)}$
- ☐  $\text{Li}^+ \text{ (g)} + \text{F}^- \text{ (g)} \rightarrow \text{LiF (s)}$
- ☐  $\text{Li}^+ \text{ (aq)} + \text{F}^- \text{ (g)} \rightarrow \text{LiF (s)}$
- ☐  $\text{Li (s)} + \frac{1}{2} \text{F}_2 \text{ (g)} \rightarrow \text{LiF (s)}$

[AQA A-level chemistry]

8. Solutions of two compounds, **W** and **X**, react together in the presence of a soluble catalyst **Y** as shown in the equation



When the concentrations of **W**, **X**, and **Y** are all doubled, the rate of reaction increases by a factor of 4.

Which of these is a possible rate equation for this reaction?

- ☐  $\text{rate} = k [\text{W}]^2 [\text{X}]$
- ☐  $\text{rate} = k [\text{W}]^2 [\text{Y}]$
- ☐  $\text{rate} = k [\text{X}] [\text{Y}]$
- ☐  $\text{rate} = k [\text{X}] [\text{Z}]$

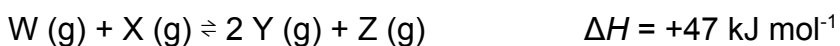
[AQA A-level chemistry]

9. The correct units for the rate constant in an overall third-order reaction are

- ☐  $\text{mol dm}^{-3} \text{s}^{-1}$
- ☐  $\text{mol}^{-1} \text{dm}^{-3} \text{s}^{-1}$
- ☐  $\text{mol}^2 \text{dm}^{-6} \text{s}^{-1}$
- ☐  $\text{mol}^{-2} \text{dm}^6 \text{s}^{-1}$

[AQA A-level chemistry]

10. For this reaction at equilibrium, which combination of conditions would give the greatest equilibrium yield of products?



- ☐ High pressure and high temperature
- ☐ High pressure and low temperature
- ☐ Low pressure and high temperature
- ☐ Low pressure and low temperature

[AQA A-level chemistry]

11. Which is the correct classification for the element yttrium (Y)?

- ☐ s block
- ☐ p block
- ☐ d block
- ☐ f block

[AQA A-level chemistry]

12. Which species is the best oxidising agent?

- ☐  $\text{Cl}_2$
- ☐  $\text{Cl}^-$
- ☐  $\text{Br}_2$
- ☐  $\text{Br}^-$

[AQA A-level chemistry]

13. Chlorine reacts with cold, dilute aqueous sodium hydroxide.

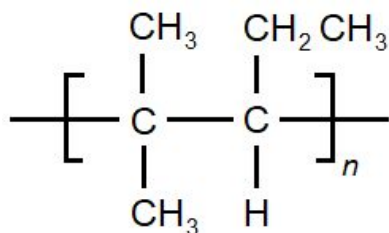
Which is a complete list of the products?

- ☐ sodium chloride, sodium chlorate(I) and water
- ☐ sodium chlorate(I) and water
- ☐ sodium chloride, sodium chlorate(V) and water
- ☐ sodium chloride and sodium chlorate(I) [AQA A-level chemistry]

14. What is the observation when a solution of silver nitrate is added to a solution containing bromide ions, and concentrated ammonia is added to the resulting mixture?

- ☐ a white precipitate soluble in concentrated aqueous ammonia
- ☐ a white precipitate insoluble in concentrated aqueous ammonia
- ☐ a cream precipitate soluble in concentrated aqueous ammonia
- ☐ a yellow precipitate insoluble in concentrated aqueous ammonia [AQA A-level chemistry]

15. The correct name for the alkene monomer which forms the polymer



is

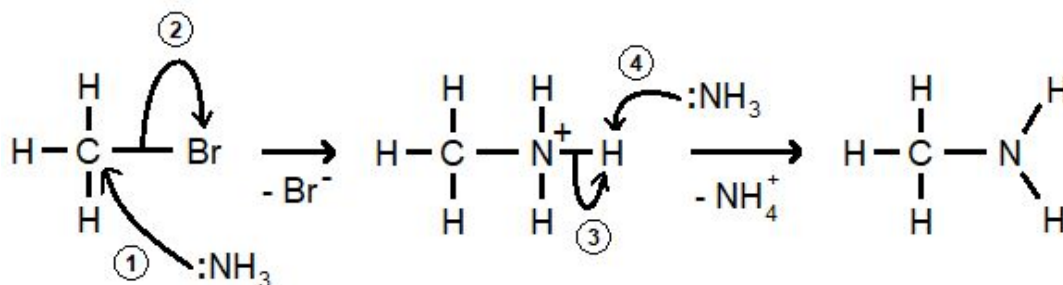
- ☐ 2-methyl-3-ethylpropene
- ☐ 2-methylpent-2-ene
- ☐ 2-methylpent-3-ene
- ☐ 4-methylpent-2-ene [AQA A-level chemistry]

16.  $\text{CH}_2\text{O}$  is the empirical formula of

- ☐ methanol
- ☐ methyl methanoate
- ☐ ethane-1,2-diol
- ☐ butanal

[AQA A-level chemistry]

17. Which of the arrows, labelled **1**, **2**, **3** or **4** in the mechanism below is **incorrect**?



- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4

[AQA A-level chemistry]

18. How many different alkenes are formed when 2-bromo-2-methylbutane reacts with ethanolic potassium hydroxide?

- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

[AQA A-level chemistry]

19. Aqueous solutions of ammonia, ethylamine and phenylamine are prepared. Each solution has the same concentration.

Which is the correct order for the pH values of these solutions?

- ☐ ammonia > ethylamine > phenylamine
  - ☐ ammonia > phenylamine > ethylamine
  - ☐ ethylamine > phenylamine > ammonia
  - ☐ ethylamine > ammonia > phenylamine
- [AQA A-level chemistry]

20. Which species has one or more bond angle(s) of  $90^\circ$ ?

- ☐  $\text{CH}_4$
  - ☐  $\text{NH}_4^+$
  - ☐  $\text{ClF}_4^-$
  - ☐  $\text{AlCl}_4^-$
- [AQA A-level chemistry]

21. Which of these species is **not** planar?

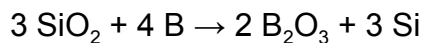
- ☐  $\text{HCHO}$
  - ☐  $\text{CH}_3^+$
  - ☐  $\text{CH}_3\text{OH}$
  - ☐  $\text{C}_2\text{H}_4$
- [AQA A-level chemistry]

22. A compound **A** is heated with aqueous sodium hydroxide solution and the products are ammonia, sodium chloride and water.

The identity of **A** is

- ☐ Ammonium chloride
- ☐ Ammonium chlorate(I)
- ☐ Nitric acid
- ☐ Nitrogen(III) chloride

23. The reducing agent in the reaction



is

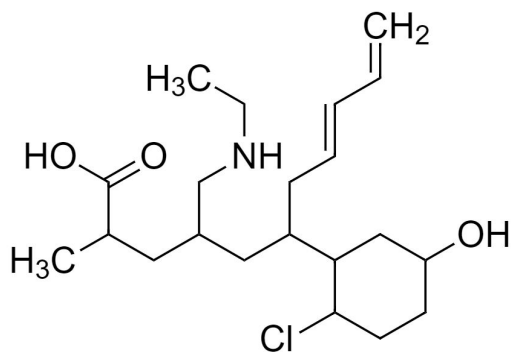
- ☐ silicon dioxide
- ☐ oxygen
- ☐ boron
- ☐ boron trioxide

[IIT JEE Advanced]

24. Which of these is a secondary haloalkane?

- ☐ 1,2-difluoroethane
- ☐ 3-chloro-1-fluoropropane
- ☐ 3-bromohexane
- ☐ 2-iodo-2-methylpropane

25.



The IUPAC name of this molecule ends in what suffix?

- ☐ -amine
- ☐ -amide
- ☐ -enoic acid
- ☐ -anoic acid

[MCAT]

26. 2,2-dibromopropane reacts with aqueous KOH followed by heating to form propanone. The intermediate compound is propane-2,2-diol.

The reactions occurring are, respectively,

- ☐ Nucleophilic substitution and dehydration
  - ☐ Elimination and condensation
  - ☐ Base hydrolysis and oxidation
  - ☐ Polymerisation and Friedel-Crafts acylation
27. Propene was reacted with steam in the presence of  $\text{H}_3\text{PO}_4$  at high temperature and pressure forming **X** and **Y** as the major and minor products respectively.

When **Y** was warmed with  $\text{K}_2\text{Cr}_2\text{O}_7$  and sulfuric acid, followed by addition of alkaline  $\text{CuSO}_4$  to the distillate collected, a red precipitate **R** is formed.

**Y** and **R** are, respectively,

- ☐ propanone and copper(II) hydroxide
  - ☐ propanone and copper(II) oxide
  - ☐ propanal and copper(I) dichromate
  - ☐ propanal and copper(I) oxide
28. Which of these is **not** a condition when the standard electrode potential of an electrochemical cell is directly measured?
- ☐  $1 \text{ mol dm}^{-3}$  concentration of each solution.
  - ☐ 298 K temperature.
  - ☐ 101 kPa pressure.
  - ☐ 1 mole of each electrode metal.



29. Three types of structures found in proteins are

- A**  $\alpha$ -helices in protein chains
- B**  $\beta$ -pleated sheets in protein chains
- C** Disulfide bridges between cysteine residues

The structures formed by hydrogen bonds are

- ☐ **A** only
- ☐ **B** only
- ☐ **A** and **B** only
- ☐ **A**, **B** and **C**

30. Which of these molecules is polar?

- ☐  $\text{PCl}_5$
- ☐  $\text{CO}_2$
- ☐  $\text{CH}_3\text{OCH}_3$
- ☐  $\text{C}_2\text{H}_4$

[AQA A-level chemistry]

31. Which of these has the most exothermic lattice enthalpy of formation?

- ☐ Lithium fluoride
- ☐ Lithium chloride
- ☐ Calcium oxide
- ☐ Calcium sulfide

32. Which of these compounds **can** be reduced by  $\text{LiAlH}_4$  but **not** by  $\text{NaBH}_4$ ?

- 1 propanoic acid
- 2 ethyl propanoate
- 3 propanone

- ☐ 1 and 2 only
- ☐ 2 and 3 only
- ☐ 1 and 3 only
- ☐ 2 only

33. Which of these ions has a relative charge of -3?

- ☐ carbonate
- ☐ phosphate
- ☐ sulfide
- ☐ hydrogensulfate

34. The numbers of sigma bonds in a molecule of  $\text{H}_3\text{PO}_4$  is

- ☐ 5
- ☐ 6
- ☐ 7
- ☐ 8

[IIE JEE Advanced]

35. In which of the following reactions is a heterogeneous catalyst **not** used?

- ☐  $\text{N}_2 + 3 \text{H}_2 \rightarrow \text{NH}_3$
- ☐  $2 \text{CO} + 2 \text{NO} \rightarrow 2 \text{CO}_2 + \text{N}_2$
- ☐  $\text{CO}_2 + \text{C} \rightarrow 2 \text{CO}$
- ☐  $2 \text{SO}_2 + \text{O}_2 \rightarrow \text{SO}_3$

[OCR A-level chemistry]

36. Which of these species does **not** act as a ligand?

- ☐  $\text{H}_2$
- ☐  $\text{O}^{2-}$
- ☐  $\text{O}_2$
- ☐  $\text{CO}$

[AQA A-level chemistry]

37. For a particular reaction,  $\Delta H^\ominus = -38.3 \text{ kJ mol}^{-1}$  and  $\Delta S^\ominus = -113 \text{ J K}^{-1} \text{ mol}^{-1}$ .  
This reaction is

- ☐ spontaneous at all temperatures
- ☐ non-spontaneous at all temperatures
- ☐ spontaneous above  $66^\circ\text{C}$
- ☐ spontaneous below  $66^\circ\text{C}$

[IIT JEE Advanced]

38. Which of these ions has the most exothermic enthalpy of hydration?

- ☐ fluoride
- ☐ chloride
- ☐ bromide
- ☐ iodide

[AQA A-level chemistry]

39. The correct conventional cell notation for a rechargeable lithium-ion cell is

- ☐  $\text{Li} \mid \text{Li}^+ \parallel \text{Li}^+, \text{Co}^{2+} \mid \text{LiCoO}_2 \mid \text{Pt}$
- ☐  $\text{Li} \mid \text{Li}^+ \parallel \text{Li}^+, \text{CoO}_2 \mid \text{LiCoO}_2 \mid \text{Pt}$
- ☐  $\text{Li} \mid \text{Li}^+ \parallel \text{CoO}_2^-, \text{Co}^{2+} \mid \text{CoO}_2 \mid \text{Pt}$
- ☐  $\text{Li} \mid \text{Li}^+ \parallel \text{Co}^{3+}, \text{CoO}_2^- \mid \text{Co} \mid \text{Pt}$

40. The correct name for the compound  $(\text{CH}_3\text{CH}_2)_3\text{NH}^+ \text{Cl}^-$  is

- ☐ *N,N,N*-trichloroethylamine
- ☐ 1,1,1-trichloroethanamide
- ☐ 1-chlorotriethylammonium
- ☐ triethylammonium chloride

41. When  $n$  molecules of benzene-1,4-dicarboxylic acid react with  $n$  molecules of ethane-1,2-diol to form a condensation polymer with  $n$  repeating units, the number of water molecules produced is
- ☐  $n - 1$
  - ☐  $2n$
  - ☐  $2n - 1$
  - ☐  $2n + 1$
42. When Fehling's solution (alkaline  $\text{CuSO}_4$ ) is added to liquid propanal,
- ☐  $\text{Cu}^{2+}$  ions are reduced to  $\text{Cu}^+$  ions.
  - ☐  $\text{Cu}^+$  ions are oxidised to  $\text{Cu}^{2+}$  ions.
  - ☐ propanal is reduced to propan-1-ol.
  - ☐ propanal is oxidised to propanone.
- [Cambridge NSAA]
43. Which of the following pairs are functional group isomers?
- ☐ hexa-2,4-diene, cyclohexane
  - ☐ propanoic anhydride, hexanedioic acid
  - ☐ 4-chlorobutanal, butanoyl chloride
  - ☐ 2-methylpropan-2-ol, butan-2-ol
- [Cambridge NSAA]
44. Which of these types of chromatography is most suitable for separating a mixture of volatile liquids?
- ☐ thin-layer chromatography
  - ☐ column chromatography
  - ☐ gas chromatography
  - ☐ paper chromatography

45. Which of these is true about silicon dioxide?

- 1 It reacts with aqueous NaOH to form sodium silicate and water.
- 2 It reacts with aqueous HCl to form silicon chloride and water.
- 3 It has no reaction with magnesium oxide.

- ☐ 1 only
- ☐ 1 and 2 only
- ☐ 2 and 3 only
- ☐ 3 only

46. Deposits of ammonium sulfate have been discovered in areas of high pollution. They are believed to arise from the following reaction:



Which of the following does **not** occur in this reaction?

- ☐ acid/base neutralisation
- ☐ dative bond formation
- ☐ ionic bond formation
- ☐ oxidation/reduction

[OCR A-level chemistry]

47. The conversions of  $\text{NH}_4^+ \rightarrow \text{NH}_3$  and of  $\text{C}_2\text{H}_4 \rightarrow \text{C}_2\text{H}_6$  both include

- ☐ a lone pair of electrons in the product.
- ☐ a change in oxidation state of an element.
- ☐ a decrease in the bond angle of the species involved.
- ☐ the disappearance of a  $\pi$  bond.

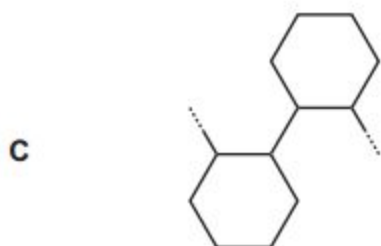
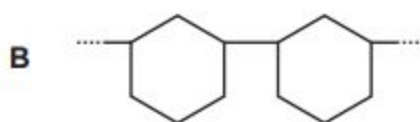
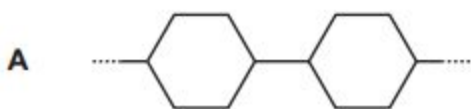
[OCR A-level chemistry]

48. When hydroxyethanal is heated with an excess of acidified potassium dichromate(V) under reflux under no more reaction is observed, the structural formula of the organic product is

- ☐  $\text{OHCCHO}$
- ☐  $\text{HOCCOOH}$
- ☐  $\text{OHCCOOH}$
- ☐  $\text{HOCCOOH}$

[OCR A-level chemistry]

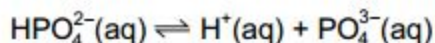
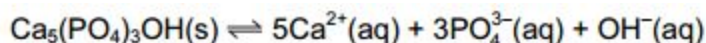
49. Which of the following shows a section with two repeating units of the polymer chain formed from the addition polymerisation of cyclohexene?



- ☐ **A**
- ☐ **B**
- ☐ **C**
- ☐ **D**

[OCR A-level chemistry]

50. Hydroxyapatite,  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ , is the main constituent of tooth enamel. In the presence of saliva, the following equilibria exist:



Which of the following statements help to explain why tooth enamel is dissolved more readily when the saliva is acidic?

- 1 The hydroxide ions are neutralised by the acid.
- 2 The phosphate ion  $\text{PO}_4^{3-}(\text{aq})$  accepts  $\text{H}^{+}(\text{aq})$ .
- 3 Calcium ions react with acids.

- ☐ 1 and 2 only
- ☐ 2 and 3 only
- ☐ 1 and 3 only
- ☐ 1, 2 and 3

[OCR A-level chemistry]

51. Several oxides of bromine have been identified. Analysis of 2.4 g of one of these compounds showed it to contain 1.6 g of bromine.

What is the empirical formula of this compound? ( $A_r$ : bromine = 80; oxygen = 16)

- ☐  $\text{BrO}_2$
- ☐  $\text{Br}_2\text{O}_5$
- ☐  $\text{Br}_4\text{O}_5$
- ☐  $\text{Br}_5\text{O}_2$

[Cambridge NSAA]

52. An oxide of iron has the formula  $\text{Fe}_3\text{O}_4$  and contains both  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  ions.

Which one of the following is the fraction of iron ions that are in the  $\text{Fe}^{2+}$  state?

- ☐ 1/4
- ☐ 1/3
- ☐ 2/3
- ☐ 1/2

[Cambridge NSAA]

53. Using your knowledge of physical properties, the **incorrect** statement is

- ☐  $\text{Bi}_2\text{O}_5$  is a more basic oxide than  $\text{N}_2\text{O}_5$
- ☐  $\text{NF}_3$  is more covalent than  $\text{BiF}_3$
- ☐  $\text{PH}_3$  boils at a lower temperature than  $\text{NH}_3$
- ☐ The N-N  $\sigma$ -bond in  $\text{N}_2\text{H}_4$  is stronger than the P-P  $\sigma$ -bond in  $\text{P}_2\text{H}_4$

[IIT JEE Advanced]

54. The sum of the number of lone pairs on the central atom in  $\text{BrF}_2^+$  and  $\text{SNF}_3$  is

- ☐ 2
- ☐ 4
- ☐ 8
- ☐ 10

[IIT JEE Advanced]

55. Consider a reaction taking place in a container in equilibrium with its surroundings. The effect of temperature on its equilibrium constant  $K_c$  in terms of the change in entropy is correctly explained by

- 1** With an increase in temperature, the value of  $K_c$  for exothermic reactions decreases because the entropy change of the reaction is positive.
- 2** With an increase in temperature, the value of  $K_c$  for endothermic reactions increases because the entropy change of the surroundings is negative.

- |                                     |   |
|-------------------------------------|---|
| <input type="radio"/> <b>1</b> only | <input type="radio"/> Both <b>1</b> and <b>2</b>    |
| <input type="radio"/> <b>2</b> only | <input type="radio"/> Neither <b>1</b> nor <b>2</b> |

[IIT JEE Advanced]

56. Listed are the electronic configurations for the atoms of different elements.

Which one represents the most reactive non-metal?

- ☐  $[\text{He}] 2s^1$
- ☐  $[\text{He}] 2s^2 2p^5$
- ☐  $[\text{Ne}] 3s^2 3p^2$
- ☐  $[\text{Ne}] 3s^2 3p^5$

[Cambridge NSAA]



57. Which row in the table correctly gives the formulae of the named ions?

	nitrate	thiosulfate	dichromate
<input type="radio"/>	$\text{NO}_3^-$	$\text{S}_2\text{O}_8^{2-}$	$\text{CrO}_4^-$
<input type="radio"/>	$\text{NO}_2^+$	$\text{SO}_4^{2-}$	$\text{Cr}_2\text{O}_7^{2-}$
<input type="radio"/>	$\text{NO}_3^-$	$\text{S}_2\text{O}_3^{2-}$	$\text{Cr}_2\text{O}_4^{2-}$
<input type="radio"/>	$\text{NO}_3^{2-}$	$\text{S}_2\text{O}_3^{2-}$	$\text{Cr}_2^{3+}$

58. An isotope's nucleus is said to have the property of spin if the number of protons and the number of neutrons are **not** both even numbers.

Which of these nuclei has spin?

- ☐  $^{16}\text{O}$
- ☐  $^{18}\text{F}$
- ☐  $^{20}\text{Ne}$
- ☐  $^{24}\text{Mg}$

59. According to the Arrhenius equation,

- ☐ a high activation energy usually implies a fast reaction
- ☐ the rate constant increases with an increase in temperature. This is due to more collisions whose energy exceeds the activation energy.
- ☐ the lower the magnitude of the activation energy, the stronger the temperature dependence of the rate constant.
- ☐ the pre-exponential factor is a measure of the rate at which collisions occur, irrespective of their energy or orientation of the reactants at collision.

[IIT JEE Advanced]

60. A 'false positive' result for Tollens' test is observed when the compound under study is an  $\alpha$ -hydroxyketone.

An example of such a compound is 3-hydroxybutan-2-one.

A **negative** result for Tollens' test is observed for (Ph = phenyl)



- ☐ (A)
- ☐ (B)
- ☐ (C)
- ☐ (D)

[IIT JEE Advanced]

61. Aqueous solutions of copper(II) chloride and lithium phosphate(V) are mixed to produce a precipitate of copper(II) phosphate(V) and an aqueous solution of lithium chloride.

Which of the following represents the balanced ionic equation for this process?

- ☐  $2 \text{Cu}^{2+} (\text{aq}) + 3 \text{PO}_4^{3-} (\text{aq}) \rightarrow \text{Cu}_2(\text{PO}_4)_3 (\text{s})$
- ☐  $3 \text{Cu}^{2+} (\text{aq}) + 2 \text{PO}_4^{3-} (\text{aq}) \rightarrow \text{Cu}_3(\text{PO}_4)_2 (\text{s})$
- ☐  $2 \text{CuCl}_2 (\text{aq}) + 3 \text{Li}_3\text{PO}_4 (\text{aq}) \rightarrow 2 \text{Cu}^{2+} (\text{s}) + 3 \text{PO}_4^{3-} (\text{s}) + 9 \text{LiCl} (\text{aq})$
- ☐  $3 \text{CuCl}_2 (\text{aq}) + 2 \text{Li}_3\text{PO}_4 (\text{aq}) \rightarrow 3 \text{Cu}^{2+} (\text{s}) + 2 \text{PO}_4^{3-} (\text{s}) + 6 \text{LiCl} (\text{aq})$

[Cambridge NSAA]

62. A sample of strontium has a relative atomic mass of 87.7 and consists of three isotopes,  $^{86}\text{Sr}$ ,  $^{87}\text{Sr}$  and  $^{88}\text{Sr}$ . The isotopes  $^{86}\text{Sr}$  :  $^{87}\text{Sr}$  are equally abundant.

What is the percentage abundance of the  $^{88}\text{Sr}$  isotope in this sample?

- ☐ 10%
- ☐ 20%
- ☐ 30%
- ☐ 40%

[AQA A-level chemistry]

63. Propanoyl chloride reacts with benzene in the presence of  $\text{AlCl}_3$ .

Which of these is **false** about this reaction?

- ☐ The reaction is a Friedel-Crafts acylation
- ☐ The mechanism is electrophilic substitution
- ☐  $\text{AlCl}_4^-$  and  $\text{CH}_3\text{CH}_2\text{CHO}^+\text{H}$  are formed as intermediates
- ☐ Adding  $\text{LiAlH}_4$  in dry ether to the product followed by ethanoyl chloride forms an ester

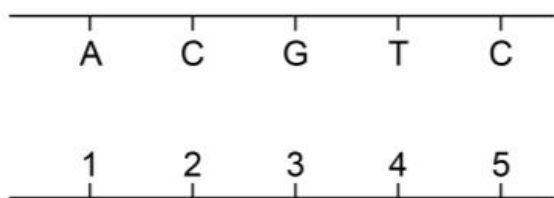
64. The structural formula of the possible dipeptides formed between alanine and cysteine in their aqueous states are

(Neglect differences due to stereoisomerism.)

- 1**  $\text{CH}_3\text{CH}(\text{NH}_3^+)\text{CONHCH}(\text{CH}_2\text{SH})\text{COO}^-$
- 2**  $\text{CH}_3\text{CH}(\text{NH}_3^+)\text{COOCH}(\text{CH}_2\text{SH})\text{COO}^-$
- 3**  $\text{HSCH}_2\text{CH}(\text{NH}_3^+)\text{CONHCH}(\text{CH}_3)\text{COO}^-$
- 4**  $^-\text{OOCCH}(\text{NH}_3^+)\text{CH}_2\text{SSCH}_2\text{CH}(\text{NH}_3^+)\text{COO}^-$

- ☐ **1 and 3**
- ☐ **2 and 4**
- ☐ **1 and 2**
- ☐ **3 and 4**

65. Below shows a fragment of a DNA double helix. The letters A, C, G and T represent the four bases in one strand. The numbers 1, 2, 3, 4 and 5 represent the bases in the complementary strand.

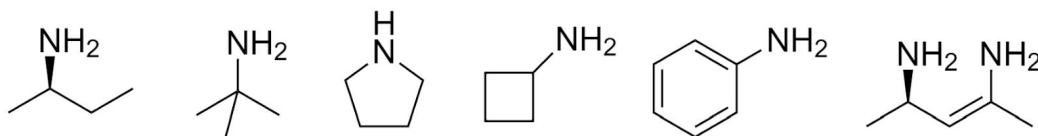


The total number of hydrogen bonds formed between the five bases in each strand in this section of the DNA is

- ☐ 10
- ☐ 12
- ☐ 13
- ☐ 15

[AQA A-level chemistry]

66. **How many** of the six amines below can be formed by the reduction of a **nitrile**?



- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3

66. Three indicators are listed below.

- 1** methyl orange
- 2** phenolphthalein
- 3** Universal Indicator

Each indicator **1**, **2** and **3** is added to a test tube containing 1 cm<sup>3</sup> of water, and then a few drops of propylamine is dissolved into the water.

What happens to the colours of the solutions?

- ☐ **1** turns from yellow to red
- ☐ **2** turns from colourless to purple/lilac
- ☐ **3** turns from green to blue
- ☐ None of the above

67. Nylon 6,6 could be made from the condensation polymerisation of

- 1** 1,6-diaminohexane and hexanedioic acid
- 2** benzene-1,4-dioic acid and hexanedinitrile
- 3** 1,6-diaminohexane and hexanoyl dichloride

- ☐ **1** and **2** only
- ☐ **2** and **3** only
- ☐ **1** and **3** only
- ☐ **1**, **2** and **3**

[AQA A-level chemistry]

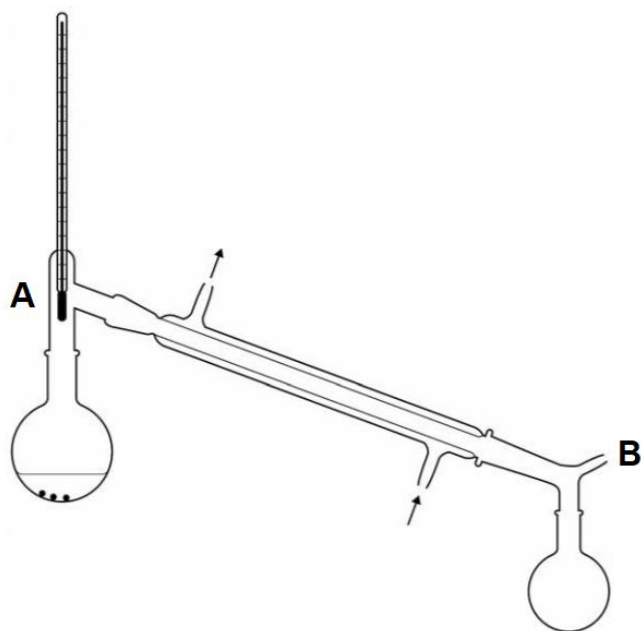
68. Platinum acts as a heterogeneous catalyst in the reaction between ammonia and oxygen. It provides an alternative reaction route with a lower activation energy.

Which of these is **not** a stage in this alternative route?

- ☐ diffusion of NH<sub>3</sub> and O<sub>2</sub> molecules to the platinum
- ☐ absorption of NH<sub>3</sub> and O<sub>2</sub> molecules into the platinum metal
- ☐ weak bond formation between reactants and platinum atoms
- ☐ desorption of the products from the platinum surface

[AQA A-level chemistry]

69. The second ionisation energy of calcium is lower than the second ionisation energy of potassium because
- ☐ The  $\text{Ca}^{2+}$  ion has a higher nuclear charge than the  $\text{K}^+$  ion
  - ☐ The  $\text{Ca}^+$  ion has its valence electron in a higher energy orbital than those of the  $\text{K}^+$  ion
  - ☐ The atomic radius of  $\text{K}^+$  is larger than that of  $\text{Ca}^+$
  - ☐ There is mutual electron repulsion in the 3p sub-orbitals of the  $\text{K}^+$  ion but no such repulsion in the 4s orbital of the  $\text{Ca}^+$  ion
70. The experimental setup for a distillation of a homogeneous liquid reaction mixture is shown below, with two parts of the glassware labelled **A** and **B**.



Which of these is **false**?

- ☐ The anti-bumping granules promote more uniform boiling and prevent large bubbles from forming
- ☐ The water entering the condenser from the lower end prevents backflow and provides more efficient cooling
- ☐ The thermometer bulb is located at junction **A** instead of in the liquid to measure the temperature of the vapours as they enter the condenser
- ☐ The junction at **B** is kept open to allow air inside and further cool the gas

71. The difference between the Al-Cl-Al and Cl-Al-Cl bond angles in the aluminium trichloride dimer is
- ☐ 0°
  - ☐ 5°
  - ☐ 10.5°
  - ☐ 19.5°
72. The correct statements regarding industrial synthesis of organic products are
- 1** Biodiesel is formed by reacting vegetable oils with glycerol in the presence of a catalyst.
  - 2** Motor fuels are produced from the catalytic cracking of long-chain alkanes distilled from crude oil.
  - 3** Soaps are made from the base hydrolysis of animal fats.
- ☐ **1** and **2** only
  - ☐ **2** and **3** only
  - ☐ **1** and **3** only
  - ☐ **1, 2** and **3**
73. The industrial advantages of choosing ethanoic anhydride over ethanoyl chloride to react with salicylic acid in the manufacture of the drug aspirin include
- 1** ethanoic anhydride is cheaper
  - 2** ethanoic anhydride is less readily hydrolysed
  - 3** the reaction with ethanoic anhydride does not produce toxic fumes
- ☐ **1** and **2** only
  - ☐ **2** and **3** only
  - ☐ **1** and **3** only
  - ☐ **1, 2** and **3**





**Section B: Standard.**

1. Which of the following statements about methyl 2-methylpropenoate is **false**?
- ☐ It displays geometrical isomerism.
  - ☐ It forms an addition polymer under suitable conditions.
  - ☐ It undergoes reduction.
  - ☐ It decolourises bromine water. [AQA A-level chemistry]

2. Chlorine exists as two isotopes  $^{35}\text{Cl}$  and  $^{37}\text{Cl}$  in the ratio 3:1.

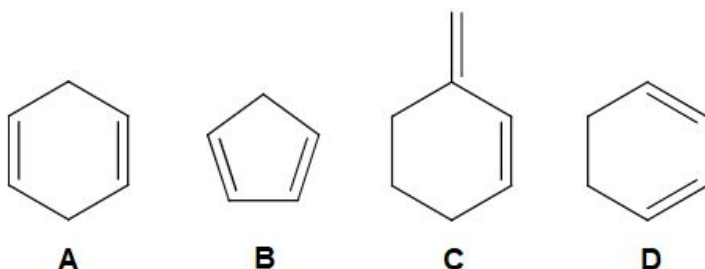
Which statement about peaks in the mass spectrum of  $\text{Cl}_2$  is correct?

- ☐ Peaks at  $m/z = 70$  and  $74$  in the ratio 3:1
  - ☐ Peaks at  $m/z = 70, 72$  and  $74$  in the ratio 9:6:1
  - ☐ Peaks at  $m/z = 70, 72$  and  $74$  in the ratio 9:3:1
  - ☐ Peaks at  $m/z = 70$  and  $72$  in the ratio 3:1 [AQA A-level chemistry]
3.  $130\text{ cm}^3$  of oxygen and  $40\text{ cm}^3$  of nitrogen, each at  $298\text{ K}$  and  $100\text{ kPa}$ , were placed into an evacuated flask of volume  $0.50\text{ dm}^3$ .

What is the pressure of the gas mixture in the flask at  $298\text{ K}$ ?

- ☐  $13.7\text{ kPa}$
- ☐  $34.0\text{ kPa}$
- ☐  $68.0\text{ kPa}$
- ☐  $294\text{ kPa}$  [AQA A-level chemistry]

4. Use your knowledge of bonding in benzene to predict which of these compounds has the most exothermic enthalpy of hydrogenation.



- ☐ **A**  
☐ **B**  
☐ **C**  
☐ **D**

[AQA A-level chemistry]

5. The choice of solvent, water or ethanol, determines whether haloalkanes will react with NaOH to form alcohols or alkenes respectively.

What can be deduced about the relative properties of ethanol and water from this information?

- ☐ Ethanol is a stronger nucleophile than water.  
☐ The O-H bond in ethanol is stronger than the O-H bond in water.  
☐ The  $\text{CH}_3\text{CO}^-$  anion is a stronger base than the hydroxide anion.  
☐ NaOH is more soluble in water than in ethanol. [Cambridge NSAA]

6. The hexafluorination of ethane to form hexafluoroethane is highly exothermic, with a standard enthalpy change of  $-2898 \text{ kJ mol}^{-1}$ .

If  $\Delta_f H^\circ$  for ethane and hexafluoroethane are  $-84 \text{ kJ mol}^{-1}$  and  $-1344 \text{ kJ mol}^{-1}$  respectively, then  $\Delta_f H^\circ$  for hydrogen fluoride is

- ☐  $-1638 \text{ kJ mol}^{-1}$   
☐  $-273 \text{ kJ mol}^{-1}$   
☐  $+273 \text{ kJ mol}^{-1}$   
☐  $+1638 \text{ kJ mol}^{-1}$

[AQA A-level chemistry]

7. A rate investigation was carried out on a reaction involving three reactants, **X**, **Y** and **Z**. The concentrations of the reactants were varied and the relative initial rate for each reaction was determined.

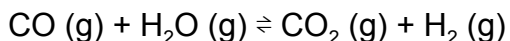
experiment	[X] / mol dm <sup>-3</sup>	[Y] / mol dm <sup>-3</sup>	[Z] / mol dm <sup>-3</sup>	relative rate
<b>1</b>	$1 \times 10^{-3}$	$1 \times 10^{-3}$	$2 \times 10^{-3}$	1
<b>2</b>	$2 \times 10^{-3}$	$2 \times 10^{-3}$	$2 \times 10^{-3}$	4
<b>3</b>	$5 \times 10^{-4}$	$2 \times 10^{-3}$	$4 \times 10^{-3}$	0.5

Given that the reaction is zero order with respect to **Y**, the overall order of this reaction is

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3

[AQA A-level chemistry]

8. Hydrogen can be produced by this reaction:



In an experiment, 4.20 mol of carbon monoxide were mixed with 2.00 mol of steam. When the reaction reached equilibrium, 1.60 mol of hydrogen had been formed.

The value of the equilibrium constant,  $K_p$ , for this reaction is

- ☐ 0.30
- ☐ 0.41
- ☐ 1.54
- ☐ 2.46

[AQA A-level chemistry]

9. Which pair of statements about trends in inorganic chemistry are correct?

- 1 The first ionisation energies of the elements in Period 3 show a general decrease from sodium to chlorine.
- 2 The electronegativities of the Group 2 elements decrease from magnesium to barium.
- 3 The strength of the intermolecular forces decreases from hydrogen fluoride to hydrogen iodide.
- 4 The ability of a halide ion to act as a reducing agent decreases from fluoride to iodide.

- ☐ 1 and 3 only
- ☐ 2 and 4 only
- ☐ 1 and 4 only
- ☐ 2 and 3 only

[OCR A-level chemistry]

10. Which alcohol can be oxidised by acidified potassium dichromate(VI) but **cannot** be dehydrated by heating with concentrated sulfuric acid?

- ☐ 2,3-dimethylbutan-2-ol
- ☐ 2,2-dimethylpropan-1-ol
- ☐ 2-methylpropan-2-ol
- ☐ pentan-3-ol

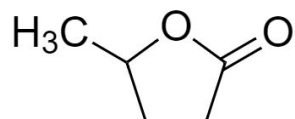
[AQA A-level chemistry]

11. Which of the following can react both by nucleophilic substitution and by nucleophilic addition?

- ☐ but-3-en-2-one
- ☐ 3-chloropropanal
- ☐ 3-chloropropene
- ☐ 1-phenylethanone

[AQA A-level chemistry]

12. Acid hydrolysis of

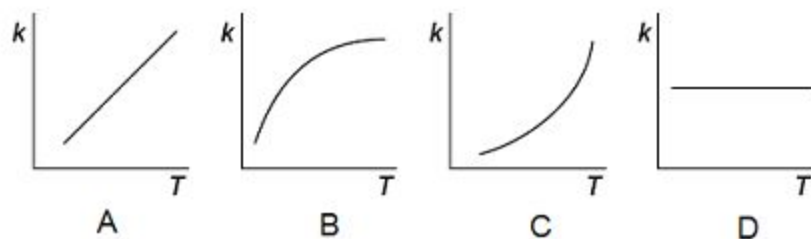


produces

- ☐  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{COOH}$
- ☐  $\text{CH}_2(\text{OH})\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH}$
- ☐  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{OCHO}$
- ☐  $\text{CH}_2(\text{OH})\text{CH}_2\text{CH}_2\text{CH}_2\text{OCHO}$

[AQA A-level chemistry]

13.

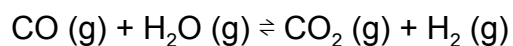


Which of the above graphs shows how the rate constant  $k$  of a reaction varies with temperature  $T$ ?

- ☐ A
- ☐ B
- ☐ C
- ☐ D

[Cambridge NSAA]

14. Consider the equilibrium shown below.



The standard enthalpies of formation of the species are shown in the table.

substance	CO (g)	H <sub>2</sub> O (g)	CO <sub>2</sub> (g)	H <sub>2</sub> (g)
$\Delta_f H^\ominus / \text{kJ mol}^{-1}$	-110	-242	-394	0

Which of the three statements below are true?

- 1** The value of  $K_p$  changes when the temperature changes.
- 2** The entropy change is more positive when the water is liquid rather than gaseous.
- 3** The enthalpy change is more positive when the water is liquid rather than gaseous.

- ☐ **1 and 2 only**
- ☐ **2 and 3 only**
- ☐ **1 and 3 only**
- ☐ **1, 2 and 3**

[AQA A-level chemistry]

15. The following tests were carried out on separate samples of two monoprotic acids, HX and HY, with  $[HX] = [HY] = 1.00 \text{ mol dm}^{-3}$ .

- 1** Measure the time taken for a 1 cm strip of magnesium to react completely when added to  $25 \text{ cm}^3$  of each acid.
- 2** Measure the volume of  $1.00 \text{ mol dm}^{-3}$  sodium hydroxide solution needed to completely neutralise  $20 \text{ cm}^3$  of each acid.
- 3** Measure the electrical conductance of each acid using circuit apparatus.

Each test was carried out under the same conditions. Which of the tests, considered independently, would show that HX was a stronger acid than HY?

- ☐ Tests **1** and **2** only
- ☐ Tests **2** and **3** only
- ☐ Tests **1** and **3** only
- ☐ All of tests **1**, **2** and **3**

[Cambridge NSAA]

16. The oxidation states of the transition metal in the compounds  $\text{CrO}_2\text{F}_2$ ,  $\text{K}_2\text{Mn}_2\text{O}_7$  and  $\text{BaTiO}_3$  respectively, are

- ☐ +6, +6, +4
- ☐ +2, +7, +3
- ☐ +4, +5, +4
- ☐ +6, +4, +3

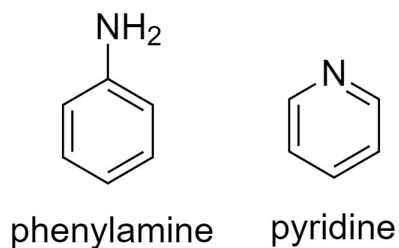
17. Which of these reactions produces a racemic mixture?

- 1** Heating but-2-ene with concentrated sulfuric acid
- 2** Hydrolysis of  $\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)(\text{OSO}_2\text{OH})\text{CH}_2\text{CH}_3$
- 3** Nickel-catalysed hydrogenation of 2,3-dimethylpent-2-ene

- ☐ **1** and **2** only
- ☐ **1** and **3** only
- ☐ **2** and **3** only
- ☐ **1**, **2** and **3**

[AQA A-level chemistry]

18. Phenylamine and pyridine are amines. Their structures are shown below.



Equimolar solutions of these amines are prepared. Which row in the table correctly identifies the stronger base of the two, and gives the correct reason?

	<i>stronger base</i>	<i>reasoning</i>
<input type="radio"/>	phenylamine	stronger positive inductive effect
<input type="radio"/>	phenylamine	lone pair in pyridine delocalised into aromatic ring
<input type="radio"/>	pyridine	stronger positive inductive effect
<input type="radio"/>	pyridine	lone pair in pyridine <b>not</b> delocalised into aromatic ring

19. The rate equation of a particular reaction between gaseous species **A** and **B** is given by: rate =  $k [\text{A}]^2 [\text{B}]$

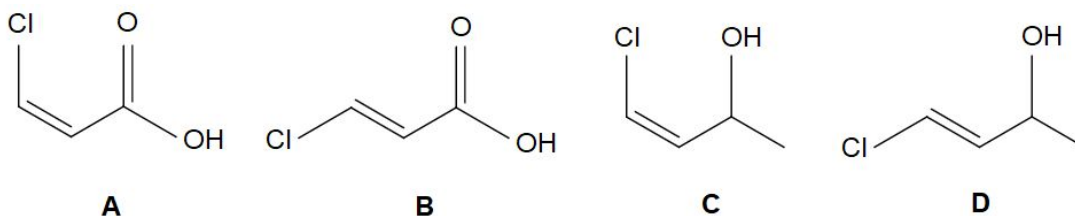
When stoichiometric amounts of the reactants are placed into a vessel of volume  $V$  at temperature  $T$ , the initial rate of reaction is  $r$ .

When the volume of the vessel is increased **by**  $4V$  while the amounts of the reactants and temperature remain the same, the initial rate of the reaction is

- ☐  $64r$
- ☐  $125r$
- ☐  $\frac{1}{64}r$
- ☐  $\frac{1}{125}r$

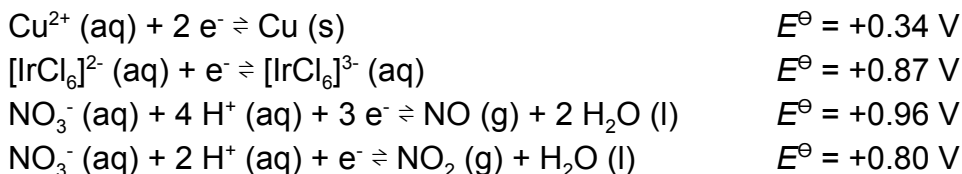


20. The compound with the highest boiling point is



- ☐ **A**  
☐ **B**  
☐ **C**  
☐ **D**

21. Some standard electrode potentials are shown.



Which of these is true?

- ☐ When an excess of nitric acid reacts with  $\text{K}_3\text{IrCl}_6$  solution, nitrogen dioxide gas is formed.  
☐ The reaction between copper and nitric acid is not feasible under standard conditions.  
☐ The cell  $\text{Cu} \mid \text{Cu}^{2+} \parallel \text{NO}_3^{-}, \text{H}^{+} \mid \text{NO} \mid \text{Pt}$  has an e.m.f. of 1.30 V.  
☐ When a platinum wire is dipped into a mixture of hexachloroiridate(III) and hexachloroiridate(IV) solutions and connected to the standard hydrogen electrode, doubling the concentration of the solution at the anode decreases the e.m.f. of the cell.

22. A chemical company has a waste tank of volume  $25 \text{ m}^3$ . The tank is full of a solution formed by adding some unwanted phosphorus(V) oxide to water in the tank. A  $25.0 \text{ cm}^3$  sample of this solution required  $21.2 \text{ cm}^3$  of  $0.500 \text{ mol dm}^{-3}$  sodium hydroxide solution for complete reaction.

The mass of phosphorus(V) oxide originally added to the tank was

- ☐ 83.7 kg
- ☐ 251 kg
- ☐ 502 kg
- ☐ 753 kg

[AQA A-level chemistry]

23. The percentage of iron in a sample of impure iron(II) sulphate crystals can be determined by titrating solutions, made from separate weighed samples acidified with dilute sulphuric acid, against a standard solution of potassium manganate(VII).

Which one of the following statements explains why dilute hydrochloric acid is unsuitable for use in this titration?

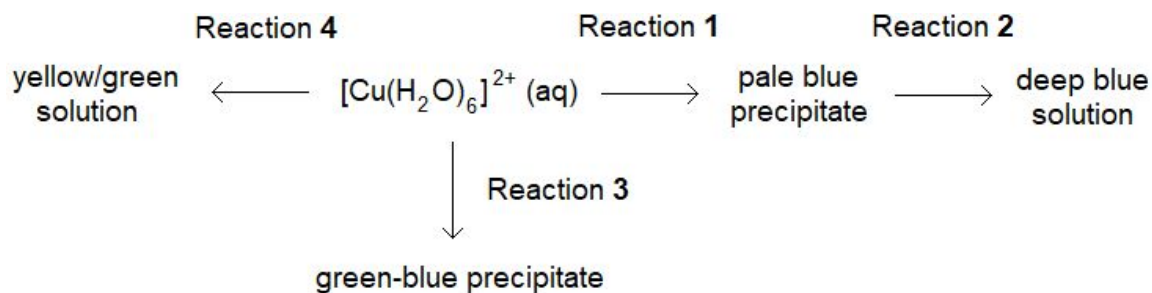
- ☐ HCl will oxidise  $\text{Fe}^{2+}$  to  $\text{Fe}^{3+}$
- ☐  $\text{Cl}^-$  will reduce  $\text{Fe}^{3+}$  to  $\text{Fe}^{2+}$
- ☐  $\text{Cl}^-$  will reduce  $\text{MnO}_4^-$
- ☐ Iron(II) sulfate forms an insoluble complex with  $\text{Cl}^-$

[AQA A-level chemistry]

24. Which of these statements regarding spectra is true?

- ☐ The  $^{13}\text{C}$  NMR spectrum of 1,3,5-trinitrobenzene has more peaks than that of 1,2-dinitrobenzene.
- ☐ Among the peaks in the  $^1\text{H}$ -NMR spectrum of 4-methylpentan-2-ol, the peak with the **smallest** integration ratio is a triplet.
- ☐ The IR spectrum of cyclopenta-2,4-dien-1-ol has a sharp absorbance peak at wavenumbers  $1680\text{-}1750 \text{ cm}^{-1}$ .
- ☐ None of the above.

25. Consider the following reaction scheme, which starts from  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  ions.



Which of these statements is true?

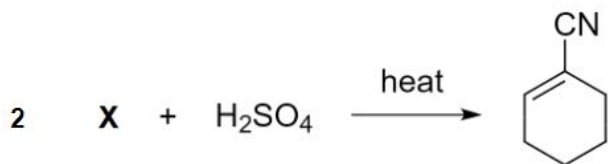
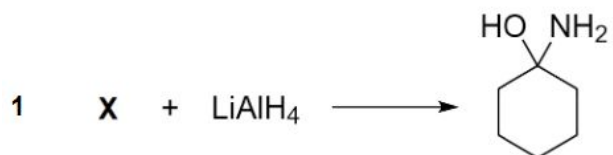
- ☐ The complexes formed from reactions **1**, **2**, **3** and **4** are, respectively:  
 $[\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2]$ ,  $[\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4]^{2+}$ ,  $\text{CuCO}_3$ ,  $[\text{Cu}(\text{H}_2\text{O})_2\text{Cl}_4]^{2-}$
- ☐ Reactions **1**, **3** and **4** are carried out with, respectively:  
excess alkaline  $\text{NH}_3 (\text{aq})$ ,  $\text{Na}_2\text{CO}_3$ , conc.  $\text{HCl}$ ,
- ☐ The complexes formed in reactions **2** and **4**, respectively, have  
octahedral and square planar geometries.
- ☐ The complex ion responsible for the deep blue solution in reaction **2**  
displays cis-trans isomerism.

[AQA A-level chemistry]

26. Cyclohexanol reacts with hot, acidic potassium dichromate, followed by aqueous sodium cyanide and dilute hydrochloric acid to form compound **X** and water.

Which of the following reactions involving **X** is/are possible?

(Neglect differences due to optical isomerism).



- ☐ 1 only
- ☐ 1 and 2 only
- ☐ 2 and 3 only
- ☐ 1 and 3 only

[OCR A-level chemistry]

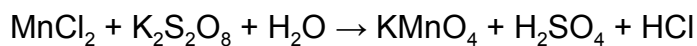
27. Which pair of statements about intermolecular forces in amines is true?
- 1** Primary and secondary amines form hydrogen bonds both in the pure state and in aqueous solution
  - 2** Tertiary amines form hydrogen bonds in aqueous solution but not in the pure state
  - 3** Quaternary ( $4^\circ$ ) ammonium salts form ion-dipole attractions in the pure state but only weak dispersion forces in aqueous solution
  - 4** The ion-dipole forces in amino acid zwitterions are stronger than the ionic attractions in  $4^\circ$  ammonium salts when both are in aqueous solutions
- ☐ **1** and **2** only
- ☐ **2** and **3** only
- ☐ **1** and **4** only
- ☐ **3** and **4** only

28. When sodium chloride dissolves in water, the resulting solution has a lower freezing point and a higher boiling point than pure water at the same pressure.

What can be correctly deduced from this information?

- ☐ Ion-dipole forces in the solution are stronger than the hydrogen bonds in the pure water.
- ☐ The enthalpy of solution for NaCl is endothermic.
- ☐ There are more hydrogen bonds formed when water is in the liquid state than in the solid state.
- ☐ The O-H bonds in the  $[\text{Na}(\text{H}_2\text{O})_6]^+$  aqueous ion are more polarised when the water is in the liquid state than in the solid state.

29. To measure the quantity of  $\text{MnCl}_2$  dissolved in an aqueous solution, it was completely converted to  $\text{KMnO}_4$  using the reaction (equation **not** balanced):



A few drops of concentrated  $\text{HCl}$  were added to this solution and gently warmed. Further, ethanedioic acid (225 mg) was added in portions until the colour of the permanganate ion disappeared.

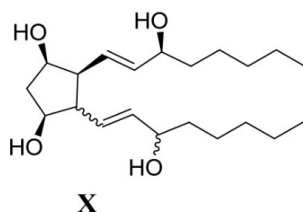
The mass of  $\text{MnCl}_2$  present in the original solution is

(Given  $A_r$ :  $\text{Mn} = 55$ ,  $\text{Cl} = 35.5$ )

- ☐ 112 mg
- ☐ 126 mg
- ☐ 132 mg
- ☐ 150 mg

[IIT JEE Advanced]

- 30.



- This type of bond indicates that the configuration at the specific carbon and the geometry of the double bond is fixed
- ~~~~ This type of bond indicates that the configuration at the specific carbon and the geometry of the double bond is **NOT** fixed

For the given compound **X**, the total number of optically active stereoisomers is

- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7

[IIT JEE Advanced]

31. An aqueous solution of the tetrachloridocuprate(II) anion,  $[\text{CuCl}_4]^{2-}$ , is a different colour to that of only aqueous copper(II) cations.

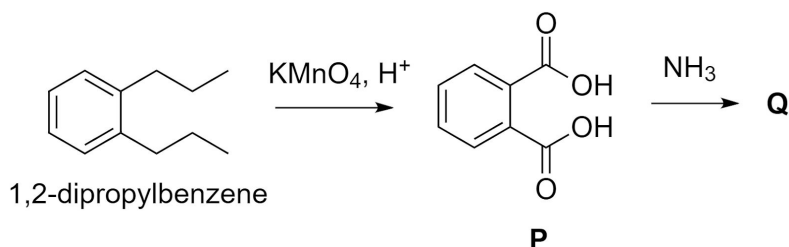
Two possible explanations are provided.

- A** the  $d$ -orbital of  $\text{Cu}^{2+}$  is split into two sets of orbitals by the  $\text{Cl}^-$  ligands, allowing electron transitions between the two energy levels, changing the frequencies at which visible photons are absorbed
- B** the energy of the Cu-Cl dative bond is different to that of the Cu- $\text{OH}_2$  dative bond, and the energy difference corresponds to that of the absorbed visible photons

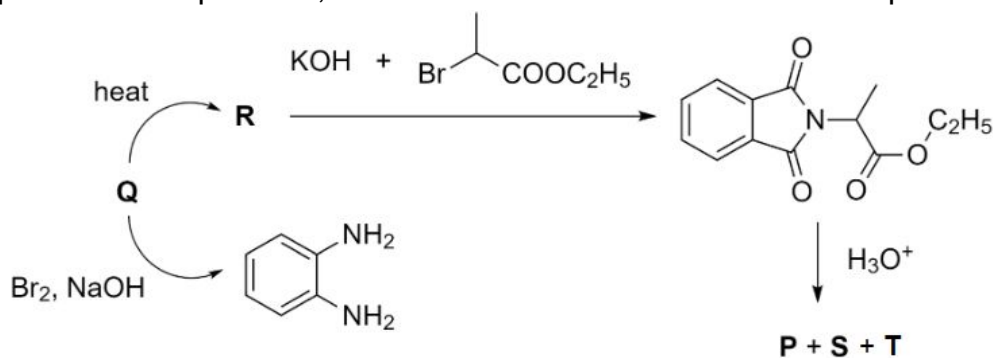
Which row in the table gives these colours, and the correct explanation?

	<i>colour of <math>\text{Cu}^{2+}</math> (aq)</i>	<i>colour of <math>[\text{CuCl}_4]^{2-}</math> (aq)</i>	<i>reason for difference</i>
<input type="radio"/>	blue	yellow-green	<b>A</b>
<input type="radio"/>	blue	yellow-green	<b>B</b>
<input type="radio"/>	colourless	deep blue	<b>A</b>
<input type="radio"/>	colourless	deep blue	<b>B</b>

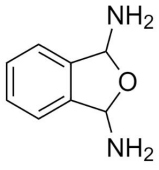
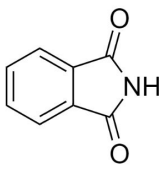
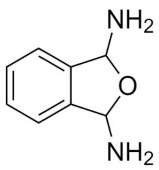
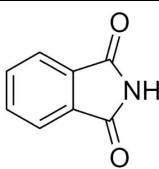
32. 1,2-dipropylbenzene is oxidised to phthalic acid (compound **P**) in acidic  $\text{KMnO}_4$ . Compound **P** then reacts with ammonia to form **Q**.



**Q** then undergoes another set of reactions through compound **R**, one of which produces compound **S**, reforms **P** and also alcohol **T** as a side product:



Which row in the table correctly identifies **R**, **S** and **T**?

	structure of <b>R</b>	common name of <b>S</b>	name of <b>T</b>
<input type="radio"/>		alanine	ethanol
<input type="radio"/>		alanine	ethanol
<input type="radio"/>		serine	propan-2-ol
<input type="radio"/>		serine	propan-2-ol



33. Aqueous carboxylate salts can undergo electrolysis to form alkanes at the anode according to the following reactions (R = alkyl group):

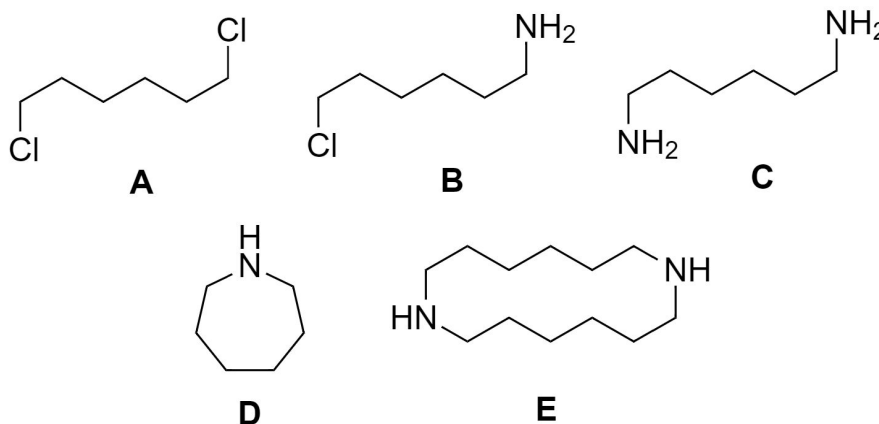


Part of the mechanism for this reaction involves the formation of two identical  $\text{R}^\bullet$  radicals which combine to form the R-R product molecule.

For which of these possible salts does the alkane product have the highest boiling point?

- ☐ sodium propanoate
- ☐ sodium butanoate
- ☐ sodium 2-methylpropanoate
- ☐ disodium butanedioate

34. Consider compounds **A-E** shown below.



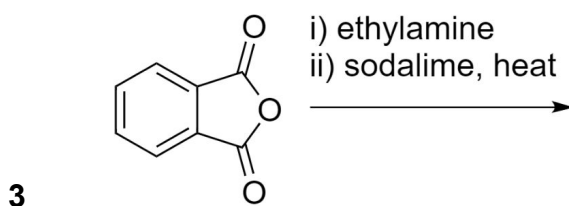
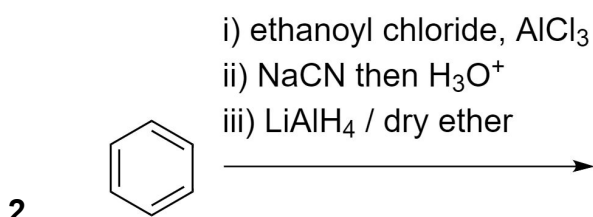
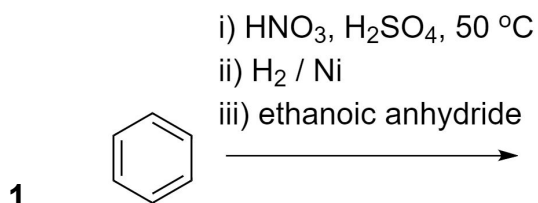
When **A** is warmed with ammonia, which of these reactions **cannot** occur in the resulting mixture?

- ☐  $\text{A} + 4 \text{ NH}_3 \rightarrow \text{C} + 2 \text{ NH}_4\text{Cl}$
- ☐  $\text{A} + \text{C} \rightarrow \text{E} + 4 \text{ NH}_4\text{Cl}$
- ☐  $\text{B} \rightarrow \text{D} + \text{HCl}$
- ☐  $2 \text{ B} \rightarrow \text{E} + 2 \text{ HCl}$

[AQA A-level chemistry]

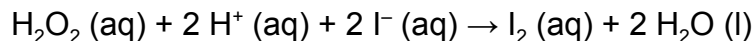
35. The reaction(s) leading to the formation of *N*-phenylethanamide are

(The indices i), ii), etc in the schemes below indicate a sequence of reactions on the major organic species.)



- ☐ **1** only
- ☐ **1** and **2** only
- ☐ **1** and **3** only
- ☐ **2** and **3** only

36. Iodide ions are oxidised to iodine by hydrogen peroxide in acidic conditions.



The rate equation for this reaction can be written as

$$\text{rate} = k_1 [\text{H}_2\text{O}_2]^a [\text{I}^-]^b [\text{H}^+]^c$$

where the reaction is at least first-order with respect to **each** reactant.

In an experiment to determine the kinetics of this reaction, a mixture is made containing  $\text{H}^+$  (aq) with a concentration of  $0.500 \text{ mol dm}^{-3}$ .

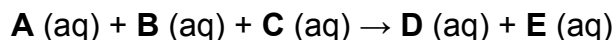
If a large excess of both  $\text{H}_2\text{O}_2$  and  $\text{I}^-$  are used in the reaction mixture, then what can the rate equation be simplified to, and why?

( $k_1$ ,  $k_2$  and  $k_3$  are rate constants with suitable units.)

	<i>simplified rate equation</i>	<i>reason</i>
<input type="radio"/>	$\text{rate} = k_2 [\text{H}_2\text{O}_2]^a [\text{I}^-]^b$	$[\text{H}^+]$ is small relative to $[\text{H}_2\text{O}_2]$ and $[\text{I}^-]$ so $[\text{H}^+]$ is approximately constant
<input type="radio"/>	$\text{rate} = k_2 [\text{H}_2\text{O}_2]^a [\text{I}^-]^b$	$[\text{H}_2\text{O}_2]$ and $[\text{I}^-]$ are large so $[\text{H}_2\text{O}_2]$ and $[\text{I}^-]$ are approximately constant
<input type="radio"/>	$\text{rate} = k_3 [\text{H}^+]^c$	$[\text{H}^+]$ is small relative to $[\text{H}_2\text{O}_2]$ and $[\text{I}^-]$ so $[\text{H}^+]$ is approximately constant
<input type="radio"/>	$\text{rate} = k_3 [\text{H}^+]^c$	$[\text{H}_2\text{O}_2]$ and $[\text{I}^-]$ are large so $[\text{H}_2\text{O}_2]$ and $[\text{I}^-]$ are approximately constant

[AQA A-level chemistry]

37. A general equation for a reaction is shown.



In aqueous solution, **A**, **B**, **C** and **D** are all colourless but **E** is dark blue.

A reagent (**X**) is available that reacts rapidly with **E**. This means that, if a small amount of **X** is included in the initial reaction mixture, it will react with any **E** produced until all of the **X** has been used up.

A student is planning to conduct a series of experiments to determine the order of this reaction with respect to **A**.

After performing the series of experiments, the student should find the gradient of the best-fit line of the graph of (**[A]** = concentration of **A**)

	quantity on x-axis	quantity on y-axis
<input type="radio"/>	<b>[A]</b>	time for dark blue to appear in reaction mixture
<input type="radio"/>	<b>[A]</b>	time for dark blue to disappear in reaction mixture
<input type="radio"/>	$\ln([\mathbf{A}])$	$1 \div (\text{time for dark blue to appear in reaction mixture})$
<input type="radio"/>	$\ln([\mathbf{A}])$	$-\ln(\text{time for dark blue to appear in reaction mixture})$

[AQA A-level chemistry]

38. An mixture of ideal gases has a density of  $3.162 \text{ g dm}^{-3}$  at temperature  $50^\circ\text{C}$  and standard pressure.

What is the average  $M_r$  of the gas mixture (in  $\text{g mol}^{-1}$ )?

- ☐ 13.1
- ☐ 20.2
- ☐ 71.8
- ☐ 84.1

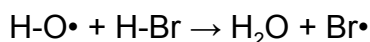
39. The acylium ion is an organic cation generated by the reaction of ethanoyl chloride with  $\text{AlCl}_3$ .

The geometry around the carbocation in an acylium ion is

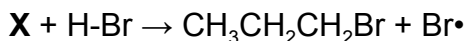
- ☐ linear
  - ☐ bent
  - ☐ trigonal planar
  - ☐ trigonal pyramidal
40. When propene gas is bubbled through an aqueous hydrogen halide, the haloalkane product is most rapidly formed with
- ☐ HF, because the H-F bond is most polar
  - ☐ HF, because the fluoride ion is smallest
  - ☐ HI, because the H-I bond is the weakest
  - ☐ HI, because the iodide ion is the strongest reducing agent
41. When aqueous hydrogen bromide reacts with propene in the presence of hydrogen peroxide, the major product is 1-bromopropane, instead of the usual 2-bromopropane when peroxide is not present.

This is due to a different reaction pathway in which free radicals form:

Initiation steps:  $\text{H-O-O-H} \rightarrow \text{H-O}\cdot + \cdot\text{O-H}$



Propagation steps:  $\text{CH}_3\text{CHCH}_2 + \text{Br}\cdot \rightarrow \text{X}$



Which of these is true?

- ☐ In species **X**, the unpaired electron lies predominantly on the 2° carbon
- ☐ 1,3-dibromo-2,3-dimethylbutane could be formed from a termination step
- ☐ In the initiation step, the O-O bond is polarised by the propene
- ☐ Hydrogen peroxide disproportionates in the initiation step

42. Chloroethanoic acid is a stronger acid than ethanoic acid. It follows that
- ☐ The charge distribution of the  $\text{COO}^-$  ion is more spread out in  $\text{CH}_3\text{COOH}$  than in  $\text{CH}_2\text{ClCOOH}$
  - ☐ The O-H bond in  $\text{CH}_2\text{ClCOOH}$  is stronger than in  $\text{CH}_3\text{COOH}$
  - ☐ The O-H bond in  $\text{CH}_2\text{ClCOOH}$  is more polarised than in  $\text{CH}_3\text{COOH}$
  - ☐ None of the above

43. A sample of a dipeptide is to be analysed by time of flight (TOF) mass spectrometry in order to determine its relative molecular mass. The sample is first reacted with

Which of the following solvents, if any, is most suitable for carrying out the electrospray ionisation process?

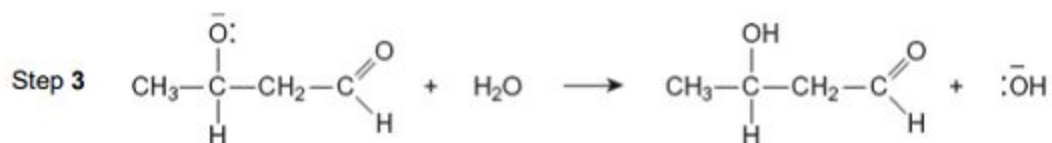
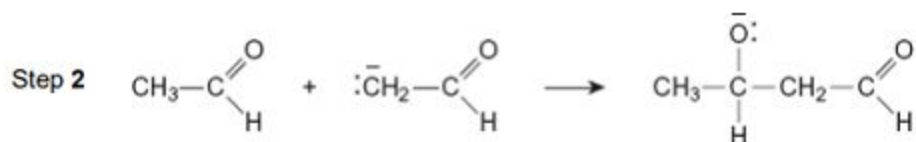
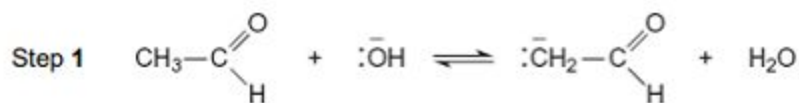
(Assume the ionisation process takes place under standard conditions.)

- ☐ water
- ☐ tetramethylsilane
- ☐ pentane-hexane mixture
- ☐ none of these



3. The kinetics of the dimerisation of ethanal into 3-hydroxybutanal in the presence of dilute alkaline solution was studied and found to be first order with respect to both ethanal and hydroxide ions.

If the mechanism for the dimerisation is



then which of the following statements is/are true?

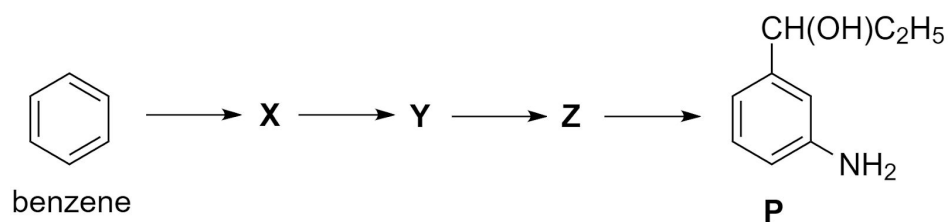
- A** The rate-determining step is Step 1  
**B** Step 2 involves nucleophilic addition  
**C** In Step 3, water acts as a base

- ☐ **A** and **B** only  
☐ **B** and **C** only  
☐ **A** and **C** only  
☐ **A**, **B** and **C**

[AQA A-level chemistry]



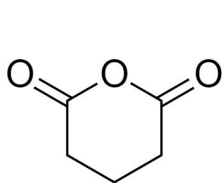
4. A reaction scheme to convert benzene to organic product **P** through three intermediate compounds **X**, **Y** and **Z** in four simple reactions is shown:



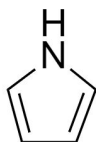
The most likely identities (by IUPAC names) of the intermediate molecules are

	<b>X</b>	<b>Y</b>	<b>Z</b>
<input type="radio"/>	benzoyl chloride	<i>N</i> -propyl benzamide	3-aminophenol
<input type="radio"/>	3-phenylpropanoic acid	phenylpropan-1-ol	1-(3-nitrophenyl)propan-1-ol
<input type="radio"/>	nitrobenzene	phenylamine	1-(3-aminophenyl)propan-1-one
<input type="radio"/>	phenol	3-aminophenol	propyl 3-aminobenzoate

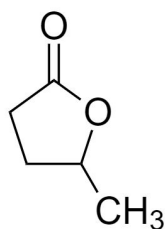
5. Compounds **A**, **B** and **C** are as shown below.



**A**



**B**



**C**

Which of the following statements is/are true?

- 1** The reaction of **A** with **B** involves nucleophilic addition-elimination
  - 2** Reduction of  $(\text{C}_5\text{H}_5)\text{CN}$  with  $\text{LiAlH}_4$  produces **B**
  - 3** Base hydrolysis of **C** followed by  $\text{HCl}$  produces an acyl chloride
- ☐ **1** only
- ☐ **2** and **3** only
- ☐ **1** and **3** only
- ☐ **1**, **2** and **3**

6. Read the information in the box below and answer the question that follows:

The Gibbs free energy change,  $\Delta G$ , varies with temperature  $T$  according to the equation  $\Delta G = \Delta G^\ominus + RT \ln \xi$ , where  $\xi$  is the *reaction quotient*, defined as the ratio of the partial pressures of the gaseous products to the partial pressures of the gaseous reactants.  $R$  is the gas constant and  $\Delta G^\ominus$  is the standard Gibbs free energy change for the same reaction.

The surface of copper gets tarnished by the formation of copper oxide. Nitrogen gas was passed over to prevent oxide formation during heating of copper at 1250 K. However, the  $N_2$  gas contains 1% (by molarity) of water vapour impurity.

The water vapour oxidises copper:  $2 \text{ Cu (s)} + \text{H}_2\text{O (g)} \rightarrow \text{Cu}_2\text{O (s)} + \text{H}_2 \text{ (g)}$ .

(You are given that: standard Gibbs free energy of formation for  $\text{Cu}_2\text{O (s)}$  and  $\text{H}_2\text{O (g)}$  are  $-78 \text{ kJ mol}^{-1}$  and  $-178 \text{ kJ mol}^{-1}$  respectively; total pressure is 100 kPa; gas constant  $R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ .)

(Assume that  $\text{Cu (s)}$  and  $\text{Cu}_2\text{O (s)}$  are mutually immiscible.)

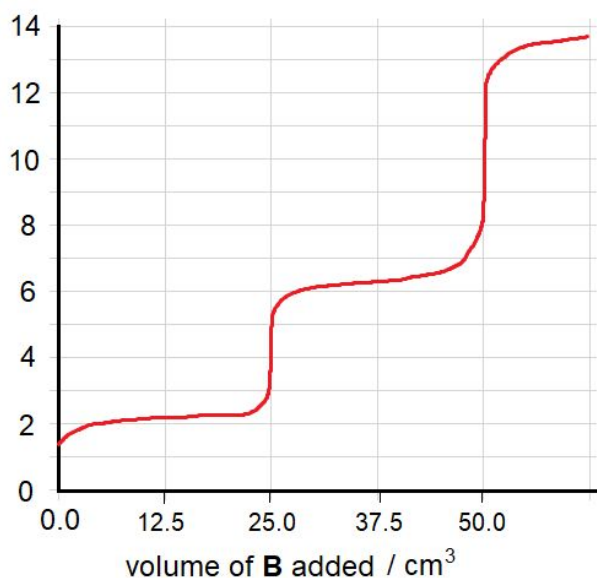
The minimum partial pressure of  $\text{H}_2$  needed to prevent the oxidation of the copper at 1250 K is

- ☐ 0.066 Pa
- ☐ 48 Pa
- ☐ 66 Pa
- ☐ 4.8 kPa

[IIT JEE Advanced]

7. An acid-base titration was carried out with a diprotic acid  $\text{H}_2\text{A}$  and a base **B**. These solutions of equal concentration were added to a conical flask and burette respectively, and a few drops of a suitable indicator were added. The pH of the solution in the flask was recorded using calibrated pH meters.

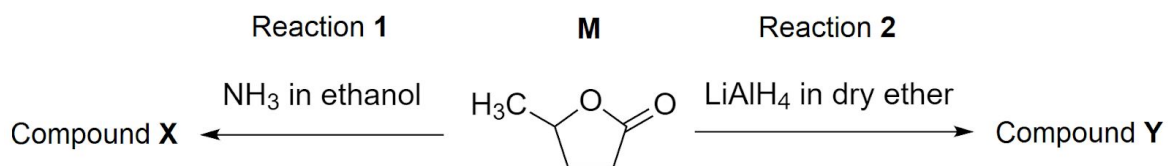
The resulting titration curve is shown below.



Which row in the table could correctly identify  $\text{H}_2\text{A}$  and **B**, as well as other relevant physical variables in this experiment based on the above titration curve (assuming the corresponding **A** and **B** are correct)?

	possible identity of $\text{H}_2\text{A}$	possible identity of <b>B</b>	initial volume of $\text{H}_2\text{A}$ / $\text{cm}^3$	$\text{p}K_{\text{a}}$ of the anion $\text{HA}^-$
<input type="radio"/>	sulfuric acid	1,2-diaminoethane	50	4.0
<input type="radio"/>	propanedioic acid	sodium hydroxide	25	6.3
<input type="radio"/>	sulfuric acid	sodium hydroxide	25	4.0
<input type="radio"/>	propanedioic acid	1,2-diaminoethane	50	2.2

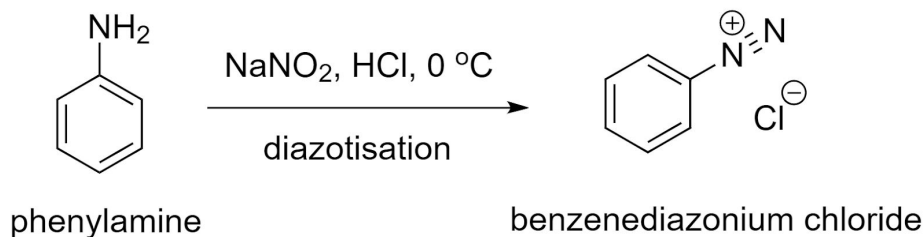
8. Consider the two reactions of the cyclic compound **M** shown, with reagents and solvents shown above each arrow.



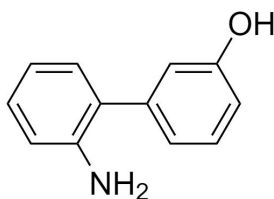
Considering **X** and **Y** as major organic products, which of the following statements are true?

- A**    Compound **X** is 4-hydroxypentanamide
  - B**    Reaction **2** followed by concentrated acid forms pentane-1,5-diol
  - C**    In the presence of dilute acid, **M** undergoes condensation polymerisation.
- 
- ☐ **A** and **B** only
  - ☐ **A** and **C** only
  - ☐ **B** and **C** only
  - ☐ **A**, **B** and **C**

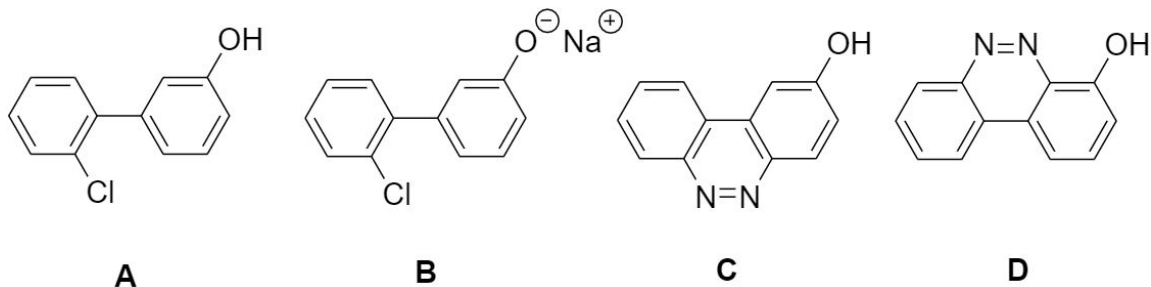
9. Phenylamine undergoes a reaction known as *diazotization* when it is mixed with sodium nitrite ( $\text{NaNO}_2$ ) and aqueous  $\text{HCl}$  at  $0^\circ\text{C}$ . The organic product of this reaction is the salt benzenediazonium chloride:



Use your knowledge of aromatic substitution reactions to predict the major product formed when



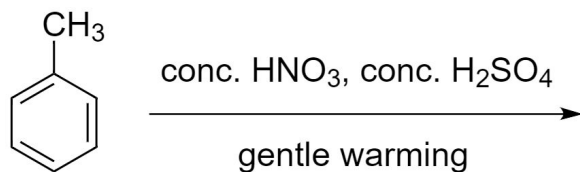
undergoes diazotization followed by treatment with aqueous  $\text{NaOH}$  catalyst.



- ☐ **A**  
☐ **B**  
☐ **C**  
☐ **D**

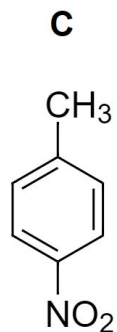
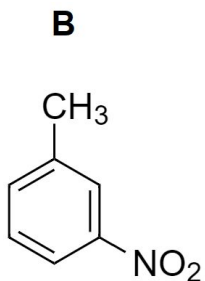
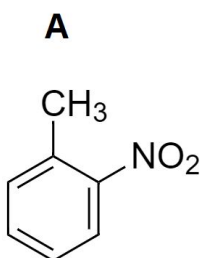
[IIT JEE Advanced]

10. By considering the Kekulé structure of methylbenzene, and using your knowledge of the positive inductive effect, predict the **major** product(s) of the following nitration reaction:



methylbenzene

(Consider only mono-nitrated product(s).)



- ☐ **A**
- ☐ **A and C**
- ☐ **B**
- ☐ **B and C**

11. Consider the following dilution processes (with deionised water):

- A** (10 cm<sup>3</sup> of 0.1 mol dm<sup>-3</sup> NaOH + 20 cm<sup>3</sup> of 0.1 mol dm<sup>-3</sup> ethanoic acid):  
diluted to 60 cm<sup>3</sup>.
- B** (20 cm<sup>3</sup> of 0.1 mol dm<sup>-3</sup> NaOH + 20 cm<sup>3</sup> of 0.1 mol dm<sup>-3</sup> ethanoic acid):  
diluted to 80 cm<sup>3</sup>
- C** (20 cm<sup>3</sup> of 0.1 mol dm<sup>-3</sup> HCl + 20 cm<sup>3</sup> of 0.1 mol dm<sup>-3</sup> ammonia solution):  
diluted to 80 cm<sup>3</sup>
- D** 10 cm<sup>3</sup> saturated solution of Ni(OH)<sub>2</sub> in equilibrium with excess solid  
Ni(OH)<sub>2</sub>: diluted to 20 cm<sup>3</sup> (solid Ni(OH)<sub>2</sub> is still present after dilution).

(It is given that nickel(II) hydroxide is a weak base. You may assume that for ethanoic acid,  $K_a \ll 1$ .)

Which of the following statements is/are correct?

- 1** In dilutions **A** and **D**, the values of [H<sup>+</sup>] do not change.
- 2** In dilution **B**, the value of [H<sup>+</sup>] halves on dilution.
- 3** In dilution **C**, the value of [H<sup>+</sup>] reduces to  $\frac{1}{\sqrt{2}}$  times its initial value.

- ☐ **1** and **2** only
- ☐ **1** and **3** only
- ☐ **2** and **3** only
- ☐ **1**, **2** and **3**

[IIT JEE Advanced]



12. The dynamic equilibrium shown below is reached at temperature  $T$  K with all species at standard pressure.



The forward reaction is second-order with respect to **A** and first-order with respect to **B**, and the backward reaction is first-order with respect to **C**.

$K_c$  is the equilibrium constant at temperature  $T$ , and  $\Delta G^\ominus$  is the standard Gibbs free energy change for the equilibrium. By considering the forward and backward rate constants for this equilibrium, it can be deduced that

(Useful identities:  $e^a/e^b = e^{a-b}$  ;  $\ln(e^a) = a$ .  $R$  is the gas constant in  $\text{J mol}^{-1} \text{ K}^{-1}$ .)

- ☐  $\Delta G^\ominus = RT \ln K_c$
- ☐  $\Delta G^\ominus = -RT \ln K_c$
- ☐  $\ln K_c = RT \Delta G^\ominus$
- ☐  $\ln K_c = -RT \Delta G^\ominus$

13. A solution was made up by dissolving 0.160 g of ammonium vanadate(V) in dilute sulphuric acid. The ammonium vanadate(V) formed  $\text{VO}_2^+$  ions in this solution. When an excess of zinc was added to this solution, the  $\text{VO}_2^+$  ions were reduced to  $\text{V}^{2+}$  ions and the zinc was oxidised to  $\text{Zn}^{2+}$  ions.

After the unreacted zinc had been removed, the solution was titrated against a  $0.0200 \text{ mol dm}^{-3}$  solution of potassium manganate(VII). In the titration,  $38.5 \text{ cm}^3$  of potassium manganate(VII) solution were required to oxidise all vanadium(II) ions to vanadium(V) ions.

Which of these is true?

- ☐ The percentage by mass of vanadium in ammonium vanadate(V) is 40.8%
- ☐ The molecular formula of ammonium vanadate is  $\text{NH}_4\text{VO}_2$
- ☐  $\text{V}^{2+}$  and  $\text{MnO}_4^-$  react together in a 4 : 3 molar ratio
- ☐  $\text{Mn}^{2+}$  acts as both an autocatalyst and an indicator in the titration

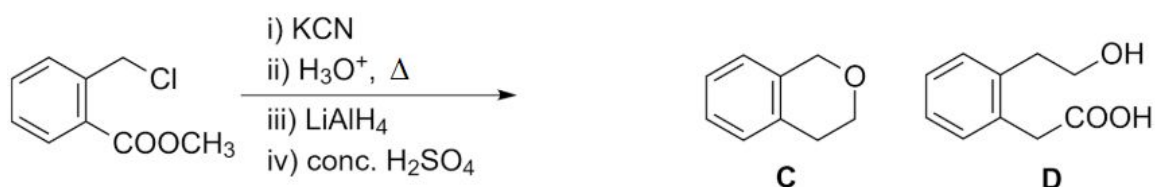
[AQA A-level chemistry]

14. Three reaction schemes starting from different aromatic compounds **X**, **Y** and **Z** are shown on the left, with six potential related compounds labelled **A-F** (in no particular order) on the right. The indices i), ii), etc. indicate a reaction sequence.

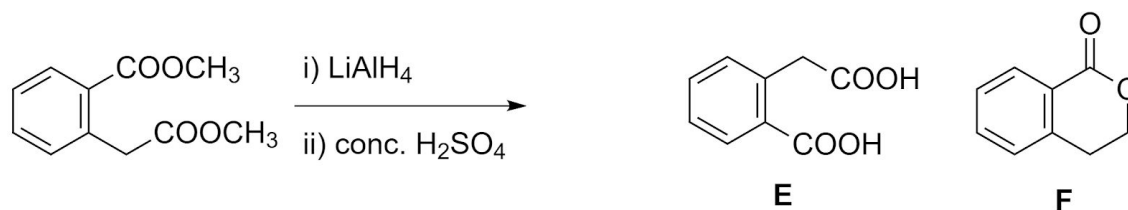
Scheme 1: Starting from compound **X**



Scheme 2: Starting from compound **Y**



Scheme 3: Starting from compound **Z**

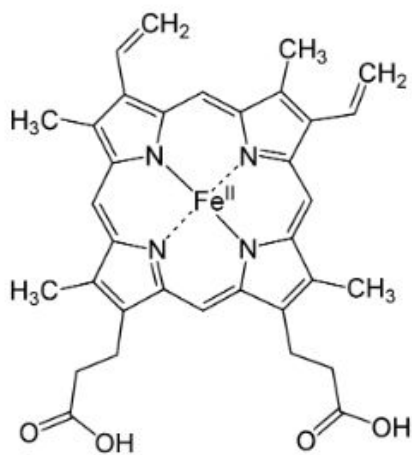


Use your knowledge of elimination mechanisms to deduce which of the following statements is true.

- ☐ Scheme 1 forms **A** and **B** as intermediate compounds.
- ☐ Compound **Y** could react with **D** or **E** followed by conc.  $\text{H}_2\text{SO}_4$  to form **F** and primary alcohols as side products.
- ☐ Scheme 3 forms **C** and **F** as the final major and minor products respectively.
- ☐ All three schemes form the same final major product.

[IIT JEE Advanced]

15. The structure of the haem B complex, a constituent of blood, is shown below, along with an extract explaining why blood is coloured red.



*“The porphyrin ring system of haem B is highly conjugated, which decreases the difference between the HOMO (highest occupied molecular orbital) and LUMO (lowest unoccupied molecular orbital) energy levels. This decreases the energy, and hence frequency, of the absorbed photons from the UV range to the green region of the visible spectrum. The remaining transmitted wavelengths appear as the complementary colour - red - to our eyes.”*

Based on this information, which of these statements is **false**?

(You are also given that:

complimentary colours are red-green, orange-blue, and yellow-violet;

wavelengths of visible light are red > orange > yellow > green > blue > violet.)

- ☐ If the porphyrin ring in haem B was slightly more saturated, it might appear yellow.
- ☐ When an oxygen ligand bonds to haemoglobin, the colour change is due to electron transitions in the central metal ion.
- ☐ If the central metal ion was  $\text{Mg}^{2+}$  instead of  $\text{Fe}^{2+}$ , the complex would appear colourless.
- ☐ The HOMO-LUMO energy difference is greater in the yellow gas  $\text{F}_2$  than in the purple solid  $\text{I}_2$ .

[IIT JEE Advanced]

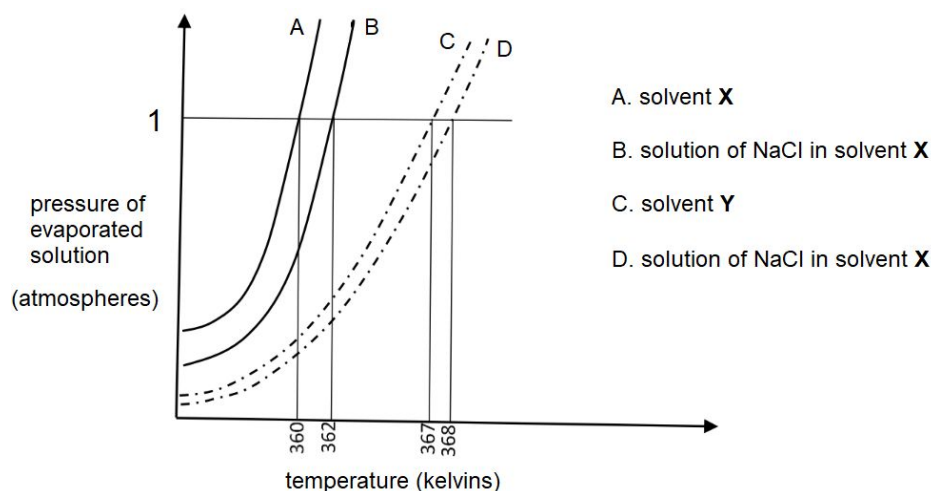
16. Read the information in the box below and answer the question that follows.

When a solute dissolves in a solvent, the boiling point of the resulting solution is higher than that of the pure solvent. This is due to the additional electrostatic forces in the solution. The boiling point elevation of a solution is given by

$$\Delta T_b = K_b \times i \times \frac{n}{m}$$

where  $\Delta T_b$  is the change in boiling point,  $i$  is the number of ions formed per dissolved unit of solute (e.g.  $\text{NaCl} = 2$ ,  $\text{Na}_2\text{SO}_4 = 3$ ),  $n$  is the moles of solute in the solution,  $m$  is the mass of the solvent, and  $K_b$  is a proportionality constant unique to the solvent.

The plot given below shows four  $P$ - $T$  curves (A, B, C, D) (where  $P$  is the partial pressure of the evaporated solution and  $T$  is the temperature) for two different solvents X and Y and solutions of NaCl for which  $n/m$  is constant in these solvents. NaCl is a strong electrolyte.



On addition of equal number of moles of a non-volatile solute **S** in equal amount mass of these solvents, the elevation of boiling point of solvent **X** is three times that of solvent **Y**.

Solute **S** is known to undergo dimerisation in these solvents. If the 70% of **S** monomers form dimers in **Y**, then the corresponding percentage in **X** is

- ☐ 5%
- ☐ 25%
- ☐ 30%
- ☐ 97.5%

[IIT JEE Advanced]