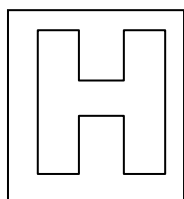


Candidate Name: \_\_\_\_\_

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## 2022 Preliminary Examination Pre-University 3

### H2 CHEMISTRY

**9729/01**

Paper 1 Multiple Choice

**21<sup>st</sup> Sep 2022**

**1 hour**

Additional materials: Multiple Choice Answer Sheet  
Data Booklet

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### READ THESE INSTRUCTIONS FIRST

**Do not turn over this question paper until you are told to do so**

Write in soft pencil.

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

Write your name, class and admission number in the spaces provided at the top of this page and on the Multiple Choice Answer Sheet provided.

There are **thirty** questions on this paper. Answer **ALL** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the Multiple Choice Answer Sheet provided.

**Read the instructions on the Multiple Choice Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this question paper.

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

| FOR EXAMINER'S USE |  |
|--------------------|--|
| TOTAL (30 marks)   |  |

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

**1** Which of the following conversions have a percentage yield of 73%?

- 1 74 g of butan-1-ol ( $M_r = 74.0$ )  $\rightarrow$  52.56 g of butanal ( $M_r = 72.0$ )
- 2 72 g of butanone ( $M_r = 72.0$ )  $\rightarrow$  54.02 g of butan-2-ol ( $M_r = 74.0$ )
- 3 56 g of but-2-ene ( $M_r = 56.0$ )  $\rightarrow$  87.60 g of ethanoic acid ( $M_r = 60.0$ )

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

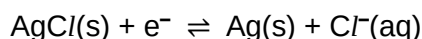
**2** Ferric oxalate,  $\text{Fe}_2(\text{C}_2\text{O}_4)_3$ , is an ionic salt. A sample of  $10.0 \text{ cm}^3$  of  $0.100 \text{ mol dm}^{-3}$  ferric oxalate is titrated against  $0.100 \text{ mol dm}^{-3}$  acidified  $\text{KMnO}_4$ .

What is the volume of  $\text{KMnO}_4$  required to reach end point, and the total volume of  $\text{CO}_2$  gas evolved at r.t.p.?

|          | volume of $\text{KMnO}_4$ | volume of gas      |
|----------|---------------------------|--------------------|
| <b>A</b> | $4.0 \text{ cm}^3$        | $72 \text{ cm}^3$  |
| <b>B</b> | $4.0 \text{ cm}^3$        | $144 \text{ cm}^3$ |
| <b>C</b> | $12.0 \text{ cm}^3$       | $72 \text{ cm}^3$  |
| <b>D</b> | $12.0 \text{ cm}^3$       | $144 \text{ cm}^3$ |

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

The silver chloride electrode is a type of reference electrode commonly used in electrochemical measurements. It can be represented as below.



The reduction potential of the  $\text{Co}^{3+}/\text{Co}^{2+}$  half-cell is  $+1.69 \text{ V}$  when it is measured using the  $\text{AgCl}/\text{Ag}$  reference electrode at standard conditions.

What is the reduction potential of the  $\text{AgCl}/\text{Ag}$  electrode when it is measured against the standard hydrogen electrode as reference?

- A**  $-1.89 \text{ V}$       **B**  $+0.20 \text{ V}$       **C**  $+1.49 \text{ V}$       **D**  $+1.89 \text{ V}$

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

Which of the following statements are true?

- 1  $\text{I}_2$  can reduce  $\text{S}_2\text{O}_3^{2-}$  to  $\text{S}_4\text{O}_6^{2-}$ .
- 2 K is a stronger reducing agent than Ca.
- 3 When  $\text{Br}_2(\text{g})$  is bubbled into  $\text{NaI}(\text{aq})$ , an orange solution is produced.

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

- 5 The first six ionisation energies of an element, **E**, in  $\text{kJ mol}^{-1}$  are shown.

578 1817 2745 11577 14842 18379

**E** forms an oxide when it is heated with oxygen gas.

What is the electronic configuration of **E** in its oxide form?

- A  $1s^2$   
B  $1s^2 2s^2 2p^1$   
C  $1s^2 2s^2 2p^6$   
D  $1s^2 2s^2 2p^6 3s^2 3p^1$

- 6 In which of the following pairs of compounds would the second compound have a higher boiling point than the first compound?

- 1  $\text{CH}_3\text{CHO}$ ,  $\text{CH}_3\text{CH}_2\text{OH}$
- 2  $\text{AlF}_3$ ,  $\text{AlCl}_3$
- 3  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ ,  $\text{C}(\text{CH}_3)_4$

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

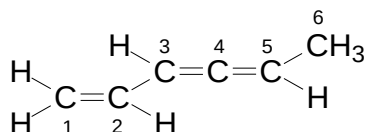
- 7 Information about the properties of some compounds are given below.

| compound         | boiling point / °C |
|------------------|--------------------|
| HF               | 19.5               |
| NH <sub>3</sub>  | -33.3              |
| H <sub>2</sub> O | 100                |

Which statement about the hydrogen bonding in these compounds is correct?

- A HF has a higher boiling point than NH<sub>3</sub> because each HF molecule can form more hydrogen bonds on average compared to each NH<sub>3</sub> molecule.
- B H<sub>2</sub>O has a higher boiling point than HF because the H–O bond dipole is greater than the H–F bond dipole.
- C H<sub>2</sub>O has a higher boiling point than HF because hydrogen bonding between two molecules of H<sub>2</sub>O causes it to dimerise.
- D NH<sub>3</sub> has the lowest boiling point because it forms few hydrogen bonds on average and has the smallest bond dipole.

- 8 Covalent bonds involve the overlapping of orbitals.

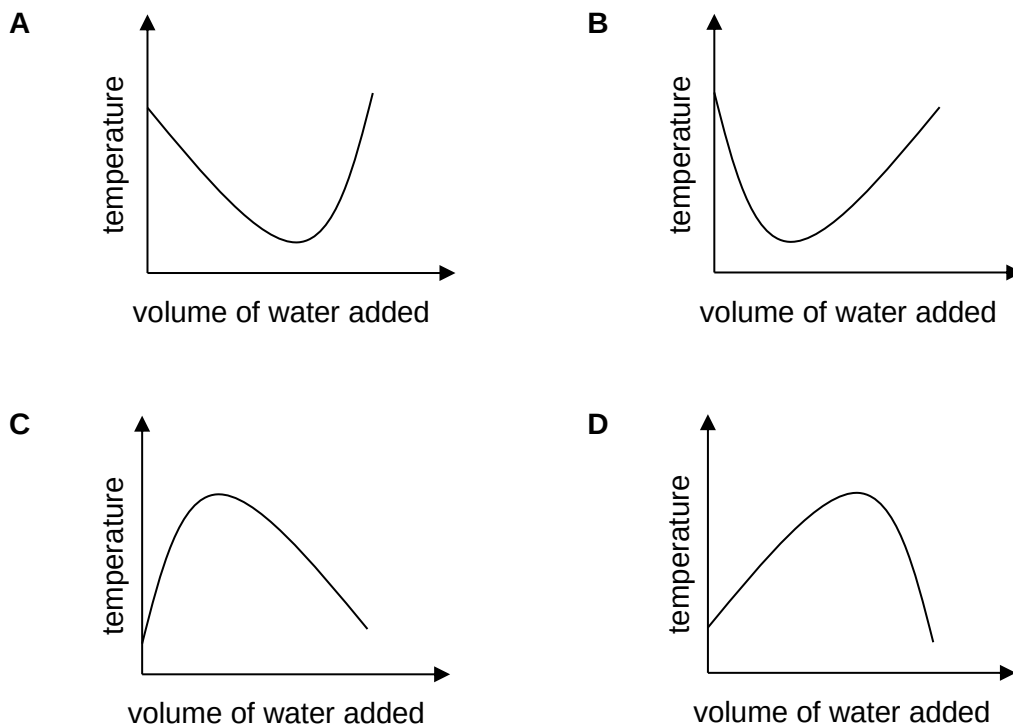


Which statement does **not** describe the molecule above?

- A The  $\sigma$  bond between C2–H is formed by  $2sp^2$ – $1s$  overlap.
- B The  $\sigma$  bond between C3–C4 is formed by  $2sp^2$ – $2sp^2$  overlap.
- C The  $\sigma$  bond between C5–C6 is formed by  $2sp^2$ – $2sp^3$  overlap.
- D The  $\pi$  bond between C4–C5 is formed by  $2p$ – $2p$  overlap.

- 9 When glucose is stirred into water and dissolved, strong hydrogen bonds are formed initially between the glucose and water molecules. As more water is added, these same hydrogen bonds are subsequently broken.

Assuming that the rate of energy change remains relatively constant throughout, which of the following graphs best represents the observed temperature changes?



- 10 The  $\Delta H_c$  values of some hydrocarbons are given below.

| hydrocarbon            | $\Delta H_c / \text{kJ mol}^{-1}$ | $M_r$ |
|------------------------|-----------------------------------|-------|
| $\text{CH}_4$          | -889                              | 16.0  |
| $\text{C}_2\text{H}_6$ | -1560                             | 30.0  |

What is the ratio of heat generated by  $\text{CH}_4$  to  $\text{C}_2\text{H}_6$  when the same mass of each hydrocarbon is burnt?

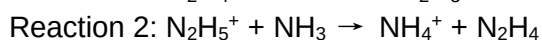
- A** 0.57      **B** 0.94      **C** 1.07      **D** 1.14

- 11** 20 m<sup>3</sup> of neon gas at a pressure of 30 kPa and 30 m<sup>3</sup> of argon gas at a pressure of 50 kPa were introduced into an evacuated 15 m<sup>3</sup> flask at a constant temperature of 300 K. The final pressure in the flask was **F** kPa.

What is the value of **F**?

|          | <b>F / kPa</b> |
|----------|----------------|
| <b>A</b> | 42             |
| <b>B</b> | 80             |
| <b>C</b> | 140            |
| <b>D</b> | 178            |

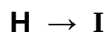
- 12** Two acid-base reactions are shown below:



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

- 1  $\text{ClO}^-$  is the conjugate base of  $\text{HClO}$ .
  - 2  $\text{N}_2\text{H}_5^+$  is the Bronsted acid in Reaction 2.
  - 3  $\text{N}_2\text{H}_4$  is the Lewis acid in Reaction 1.
- A** 1 only  
**B** 3 only  
**C** 1 and 2 only  
**D** 2 and 3 only

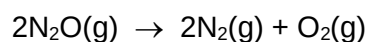
- 13** The radioactive decay of an element, **H**, is a first order reaction and produces element **I** as the product:



1.00 mol of **H** was set aside and allowed to decay. Given that it takes 8 days for 0.75 mol of **I** to be produced, what fraction of **H** remains after 40 days?

- A**  $\left(\frac{1}{2}\right)^1$       **B**  $\left(\frac{1}{2}\right)^5$       **C**  $\left(\frac{1}{2}\right)^{10}$       **D**  $\left(\frac{1}{2}\right)^{25}$

- 14  $\text{N}_2\text{O}$  decomposes in the presence of gold catalyst as follows:



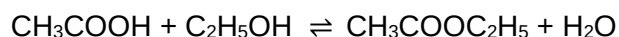
The following data is obtained from an experiment carried out at 1200 K.

|                                                |      |      |      |      |      |
|------------------------------------------------|------|------|------|------|------|
| time / s                                       | 0    | 1040 | 2370 | 4250 | 7460 |
| partial pressure of $\text{N}_2\text{O}$ / kPa | 25.0 | 20.0 | 15.0 | 10.0 | 5.0  |

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

- A The reaction is first order with respect to  $\text{N}_2\text{O}$ .
- B The total pressure upon reaction completion can be determined from the above data.
- C The values of the partial pressures of  $\text{N}_2\text{O}$  are affected by temperature.
- D The value of rate constant of the reaction remains the same even in the absence of gold.

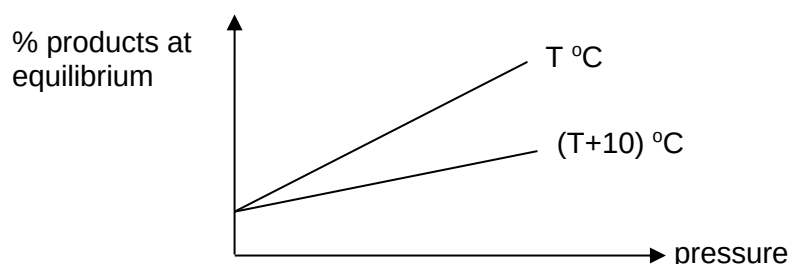
15



Which of the following conditions will be met when the above reaction has reached dynamic equilibrium?

- A The equilibrium constant  $K$  is equal to 1.
- B The reaction between the acid and the alcohol has stopped.
- C The concentrations of the products equal those of the reactants.
- D The rate of production of ethyl ethanoate equals its rate of hydrolysis.

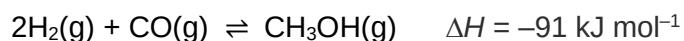
- 16 The graph below shows the percentage of products present at equilibrium over a range of temperatures and pressures.



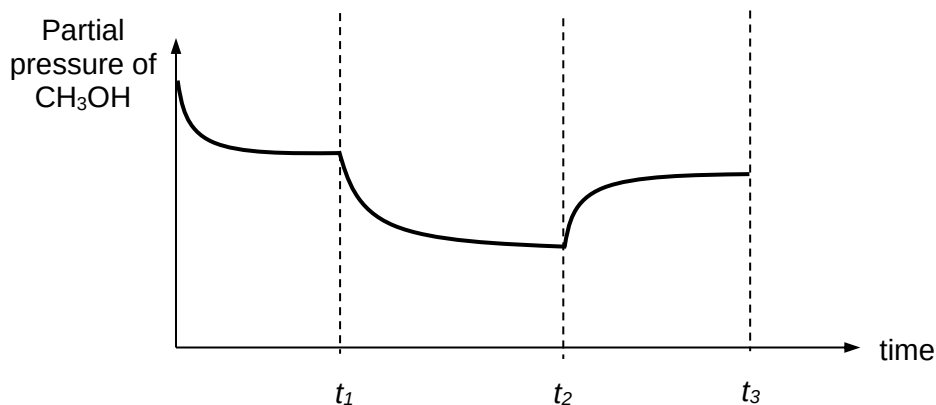
Which of the following reactions could the graph represent?

- A  $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{CO}(\text{g})$   $\Delta H = -99 \text{ kJ mol}^{-1}$
- B  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$   $\Delta H = +20 \text{ kJ mol}^{-1}$
- C  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$   $\Delta H = -92 \text{ kJ mol}^{-1}$
- D  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$   $\Delta H = +57 \text{ kJ mol}^{-1}$

- 17 A synthesis was carried out to produce methanol from hydrogen and carbon monoxide at a high temperature:



The partial pressure of  $\text{CH}_3\text{OH}(\text{g})$  was monitored over time, and changes were made to the reaction system at times  $t_1$  and  $t_2$ .



What are the possible changes made to the system at  $t_1$  and  $t_2$ ?

|   | $t_1$                              | $t_2$                            |
|---|------------------------------------|----------------------------------|
| A | $\text{CH}_3\text{OH}$ was removed | Temperature was increased        |
| B | $\text{CO}$ was removed            | Temperature was decreased        |
| C | Temperature was increased          | $\text{CO}$ was removed          |
| D | Temperature was decreased          | $\text{CH}_3\text{OH}$ was added |

- 18 Pure water undergoes slight auto-ionisation:



Which of the following equations about water at  $10^\circ\text{C}$  is true?

- A  $\text{pH} > 7$
- B  $\text{pH} = 7$
- C  $\text{pH} < 7$
- D  $[\text{H}^+] < [\text{OH}^-]$



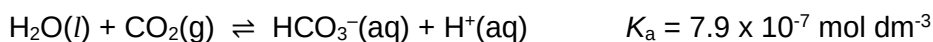
- 19 Trimethylamine,  $(\text{CH}_3)_3\text{N}$ , has a  $\text{p}K_{\text{b}}$  of 4.1.

10.0  $\text{cm}^3$  of 0.1  $\text{mol dm}^{-3}$   $(\text{CH}_3)_3\text{N}$  was pipetted into a conical flask and titrated against 10.00  $\text{cm}^3$  of 0.1  $\text{mol dm}^{-3}$   $\text{HCl}$ .

Which of the following statements is true about the pH of the reaction mixture?

|   | before addition of $\text{HCl}$ | after adding 10.00 $\text{cm}^3$ $\text{HCl}$ |
|---|---------------------------------|-----------------------------------------------|
| A | 11.5                            | 5.6                                           |
| B | 11.5                            | 9.9                                           |
| C | 13.8                            | 5.6                                           |
| D | 13.8                            | 9.9                                           |

- 20 The blood buffer system in the human body which maintains the pH of blood at 7.40 can be represented with the following equilibrium:



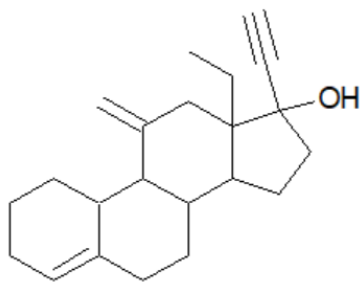
Which of the following statements about the blood buffer system is **not** true?

- A During vigorous exercise which produces large amounts of lactic acid in the blood, the body regulates pH by exhaling more  $\text{CO}_2$ .
- B When a person hyperventilates (breathes in and out excessively quickly), the loss of  $\text{CO}_2$  causes the pH of blood to increase slightly.
- C The pH of blood is 7.40 when the ratio of  $[\text{HCO}_3^-] : [\text{CO}_2]$  is 16:1.
- D The blood buffer system is made up of  $\text{H}_2\text{CO}_3$  and  $\text{HCO}_3^-$ .
- 21  $\text{Ag}_2\text{CO}_3$  is a sparingly soluble salt with a  $K_{\text{sp}}$  value of  $8.2 \times 10^{-12} \text{ mol}^3 \text{ dm}^{-9}$ .

Which one of the following statements about a solution containing solid  $\text{Ag}_2\text{CO}_3$  is correct?

- A Addition of  $\text{NaCl}(\text{aq})$  causes more  $\text{Ag}_2\text{CO}_3$  solid to dissolve.
- B Addition of sodium carbonate increases the solubility of  $\text{Ag}_2\text{CO}_3$ .
- C Addition of  $\text{AgNO}_3$  solution decreases the  $K_{\text{sp}}$  value of  $\text{Ag}_2\text{CO}_3$ .
- D Addition of water decreases the solubility of  $\text{Ag}_2\text{CO}_3$ .

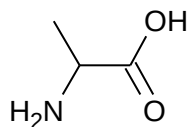
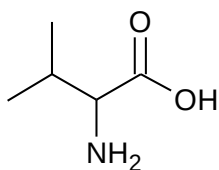
- 22 Desogestrel is a medication used in birth control pills.



desogestrel

How many stereoisomers does desogestrel have?

- A  $2^4$                       B  $2^5$                       C  $2^6$                       D  $2^7$
- 23 The structures of two amino acids are given below.



Which of the following statements about the amino acids is correct?

- A Both compounds are able to form zwitterions.
- B Both compounds are able to react with ethanoic acid in the presence of concentrated sulfuric acid to give an amide.
- C Both compounds are able to react with  $\text{NaBH}_4$  in methanol to give an alcohol.
- D Both compounds are soluble in water due to the formation of intermolecular hydrogen bonding.

24 Benzene, C<sub>6</sub>H<sub>6</sub>, is a non-polar molecule.

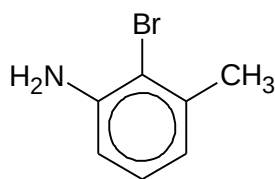
Which of the following statements are true about benzene?

- 1 Benzene is a good conductor of electricity due to its delocalised  $\pi$  electrons.
- 2 Benzene undergoes addition reactions readily due to its unsaturated C=C bonds.
- 3 The enthalpy change of hydrogenation of benzene is less exothermic than that predicted for cyclohexatriene.
- 4 The C–C bond lengths in benzene are all equivalent, and shorter than a typical alkane C–C bond length.

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

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

Compound **J** can be synthesised starting from benzene.

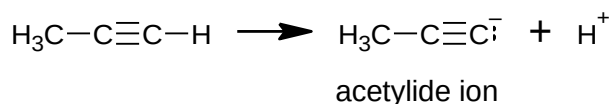


**J**

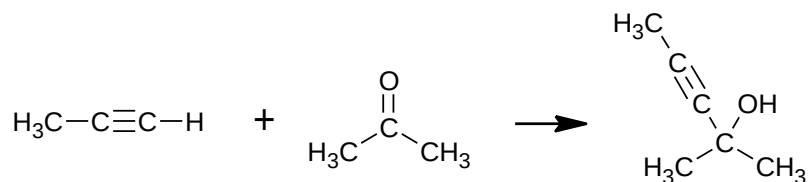
Which of the following synthetic routes will yield the optimum amount of **J**?

- A** alkylation → bromination → nitration → reduction  
**B** alkylation → nitration → reduction → bromination  
**C** bromination → alkylation → nitration → reduction  
**D** bromination → nitration → alkylation → reduction

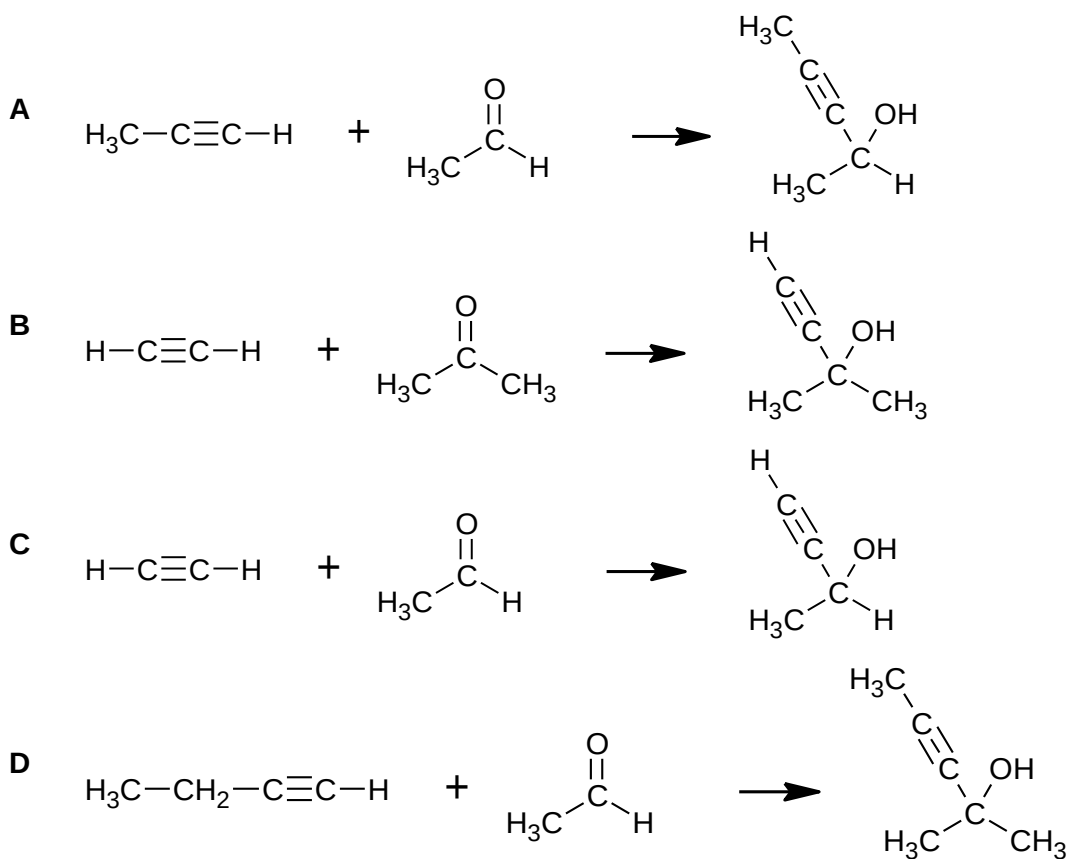
- 26 Alkynes can be deprotonated to form strong nucleophilic ions known as acetylides.



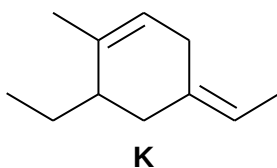
The acetylide ion can react with carbonyl compounds. An example of such a reaction is shown below:



Which of the following reaction schemes does **not** show the correct corresponding product formed?



- 27 Compound **K** has the following structure:



Which of the following statements are correct when **K** is treated with hot acidified  $\text{KMnO}_4$ ?

- 1 There is only one organic product.
- 2 The product(s) contain at least one carbonyl functional group.
- 3 The product(s) contain at least one carboxylic acid functional group.

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

- 28 A Period 3 chloride and Period 3 oxide are dissolved in two separate portions of water to form aqueous solutions.

Both of the resulting solutions can be used to dissolve  $\text{Al}_2\text{O}_3$  but only one of the two can dissolve  $\text{SiO}_2$  slightly.

Which of the following could be the chloride and the oxide used?

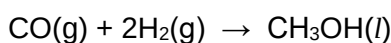
- 1  $\text{PCl}_5$        $\text{P}_4\text{O}_{10}$
- 2  $\text{MgCl}_2$        $\text{SO}_3$
- 3  $\text{SiCl}_4$        $\text{Na}_2\text{O}$

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

- 29 Which of the following correctly describes the complex formed when different reagents are added to solid copper(II) sulfate?

|   | reagent added                    | colour of resultant solution | identity of coloured complex ion                                                   |
|---|----------------------------------|------------------------------|------------------------------------------------------------------------------------|
| A | H <sub>2</sub> O                 | pale blue                    | [Cu(H <sub>2</sub> O) <sub>6</sub> ] <sup>2+</sup>                                 |
| B | H <sub>2</sub> O, followed by Zn | pink                         | [Cu(H <sub>2</sub> O) <sub>6</sub> ] <sup>2+</sup>                                 |
| C | conc. HCl                        | yellow                       | [CuCl <sub>4</sub> ] <sup>2-</sup>                                                 |
| D | excess NH <sub>3</sub> (aq)      | dark blue                    | [Cu(NH <sub>3</sub> ) <sub>4</sub> (H <sub>2</sub> O) <sub>2</sub> ] <sup>2+</sup> |

- 30 Solid Cr<sub>2</sub>O<sub>3</sub> can be used as a catalyst in the synthesis of methanol.



Which of the following statements is **false** about the use of Cr<sub>2</sub>O<sub>3</sub> in this synthesis?

- A Cr<sub>2</sub>O<sub>3</sub> functions as a catalyst by increasing the concentration of reactant molecules on its surface.
- B Cr<sub>2</sub>O<sub>3</sub> lowers the activation energy by using its partially filled 3d orbitals for the adsorption of reactant molecules.
- C The Cr atom of Cr<sub>2</sub>O<sub>3</sub> is able to form temporary bonds to the reactants.
- D The oxidation state of Cr is increased after the reaction.

END OF PAPER 1

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