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**CHEMISTRY
HIGHER LEVEL
PAPER 1**

Monday 9 May 2011 (afternoon)

1 hour

INSTRUCTIONS TO CANDIDATES

- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.

1. What is the total number of hydrogen atoms in 1.0 mol of benzamide, $C_6H_5CONH_2$?
- A. 7
- B. 6.0×10^{23}
- C. 3.0×10^{24}
- D. 4.2×10^{24}

2. Chloroethene, C_2H_3Cl , reacts with oxygen according to the equation below.



What is the amount, in mol, of H_2O produced when 10.0 mol of C_2H_3Cl and 10.0 mol of O_2 are mixed together, and the above reaction goes to completion?

- A. 4.00
- B. 8.00
- C. 10.0
- D. 20.0
3. What is the concentration of $NaCl$, in $mol\,dm^{-3}$, when 10.0 cm^3 of 0.200 $mol\,dm^{-3}$ $NaCl$ solution is added to 30.0 cm^3 of 0.600 $mol\,dm^{-3}$ $NaCl$ solution?
- A. 0.450
- B. 0.300
- C. 0.500
- D. 0.800

4. Consider the relative abundance of the isotopes of element X.

| Isotope | Relative abundance (%) |
|-----------------|------------------------|
| ^{24}X | 80 |
| ^{25}X | 10 |
| ^{26}X | 10 |

What is the relative atomic mass of X?

- A. 24
- B. 25
- C. Between 24 and 25
- D. Between 25 and 26
5. In the emission spectrum of hydrogen, which electronic transition would produce a line in the visible region of the electromagnetic spectrum?
- A. $n = 2 \rightarrow n = 1$
- B. $n = 3 \rightarrow n = 2$
- C. $n = 2 \rightarrow n = 3$
- D. $n = \infty \rightarrow n = 1$

6. Values for the successive ionization energies for an unknown element are given in the table below.

| First ionization energy / kJ mol^{-1} | Second ionization energy / kJ mol^{-1} | Third ionization energy / kJ mol^{-1} | Fourth ionization energy / kJ mol^{-1} |
|--|---|--|---|
| 420 | 3600 | 4400 | 5900 |

In which group of the periodic table would the unknown element be found?

- A. 1
- B. 2
- C. 3
- D. 4
7. Which pair of elements has the greatest difference in electronegativity?
- A. Cs and F
- B. Cs and Cl
- C. Cs and Br
- D. Cs and I
8. Ligands can form dative covalent bonds with metal ions to form complex ions. Which of the following can act as a ligand?
- I. Cl^-
- II. NH_3
- III. H_2O
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III

9. Which metal nitrate solution is coloured?
- A. $\text{Zn}(\text{NO}_3)_2(\text{aq})$
 - B. $\text{Ni}(\text{NO}_3)_2(\text{aq})$
 - C. $\text{Mg}(\text{NO}_3)_2(\text{aq})$
 - D. $\text{Sc}(\text{NO}_3)_3(\text{aq})$
10. When C_2H_2 , C_2H_4 and C_2H_6 are arranged in order of **increasing** carbon-carbon bond strength (weakest bond first), what is the correct order?
- A. C_2H_2 , C_2H_4 , C_2H_6
 - B. C_2H_2 , C_2H_6 , C_2H_4
 - C. C_2H_6 , C_2H_4 , C_2H_2
 - D. C_2H_6 , C_2H_2 , C_2H_4
11. Which molecule has a non-bonding (lone) pair of electrons around the central atom?
- A. BF_3
 - B. SO_2
 - C. PCl_5
 - D. SiF_4
12. Which particles are responsible for the conduction of electricity in molten aluminium?
- A. Cations
 - B. Anions
 - C. Electrons
 - D. Protons

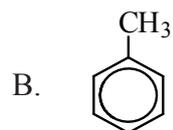
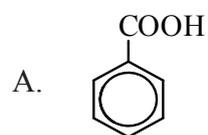
13. How many sigma and pi bonds are there in propyne, CH_3CCH ?

- A. 2 sigma and 2 pi
- B. 7 sigma and 1 pi
- C. 6 sigma and 2 pi
- D. 5 sigma and 3 pi

14. Which species does **not** have delocalized electrons?

- A. NO_3^-
- B. NO_2^-
- C. O_3
- D. C_3H_6

15. In which compound are all the carbon atoms sp^2 hybridized?



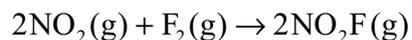
16. Which ionic compound has the greatest lattice enthalpy?
- A. MgO
 - B. CaO
 - C. NaF
 - D. KF
17. Which equation represents the bond enthalpy for the H-Br bond in hydrogen bromide?
- A. $\text{HBr(g)} \rightarrow \text{H(g)} + \text{Br(g)}$
 - B. $\text{HBr(g)} \rightarrow \text{H(g)} + \text{Br(l)}$
 - C. $\text{HBr(g)} \rightarrow \text{H(g)} + \frac{1}{2}\text{Br}_2(\text{l})$
 - D. $\text{HBr(g)} \rightarrow \text{H(g)} + \frac{1}{2}\text{Br}_2(\text{g})$
18. Which change will **not** increase the entropy of a system?
- A. Increasing the temperature
 - B. Changing the state from liquid to gas
 - C. Mixing different types of particles
 - D. A reaction where four moles of gaseous reactants changes to two moles of gaseous products
19. ΔG^\ominus calculations predict that a reaction is always spontaneous for which of the following combinations of ΔH^\ominus and ΔS^\ominus ?
- A. $+\Delta H^\ominus$ and $+\Delta S^\ominus$
 - B. $+\Delta H^\ominus$ and $-\Delta S^\ominus$
 - C. $-\Delta H^\ominus$ and $-\Delta S^\ominus$
 - D. $-\Delta H^\ominus$ and $+\Delta S^\ominus$

20. Sodium carbonate and hydrochloric acid react according to the equation below.



Which conditions will produce the fastest initial rate with 2.0 g of powdered sodium carbonate?

- A. 100 cm³ of 1.0 mol dm⁻³ hydrochloric acid at 323 K
- B. 50 cm³ of 2.0 mol dm⁻³ hydrochloric acid at 323 K
- C. 100 cm³ of 1.0 mol dm⁻³ hydrochloric acid at 348 K
- D. 50 cm³ of 2.0 mol dm⁻³ hydrochloric acid at 348 K
21. The rate information below was obtained for the following reaction at a constant temperature.

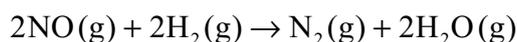


| [NO ₂] / mol dm ⁻³ | [F ₂] / mol dm ⁻³ | Rate / mol dm ⁻³ s ⁻¹ |
|---|--|---|
| 2.0 × 10 ⁻³ | 1.0 × 10 ⁻² | 4.0 × 10 ⁻⁴ |
| 4.0 × 10 ⁻³ | 1.0 × 10 ⁻² | 8.0 × 10 ⁻⁴ |
| 4.0 × 10 ⁻³ | 2.0 × 10 ⁻² | 1.6 × 10 ⁻³ |

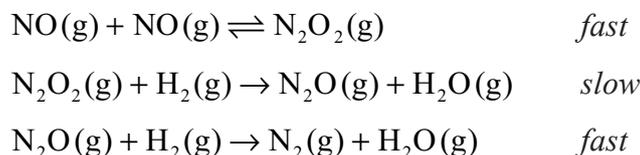
What are the orders of the reaction with respect to NO₂ and F₂?

- A. NO₂ is first order and F₂ is second order
- B. NO₂ is second order and F₂ is first order
- C. NO₂ is first order and F₂ is first order
- D. NO₂ is second order and F₂ is second order

22. Consider the following reaction.



A proposed reaction mechanism is:



What is the rate expression?

- A. $\text{rate} = k[\text{H}_2][\text{NO}]^2$
- B. $\text{rate} = k[\text{N}_2\text{O}_2][\text{H}_2]$
- C. $\text{rate} = k[\text{NO}]^2[\text{H}_2]^2$
- D. $\text{rate} = k[\text{NO}]^2[\text{N}_2\text{O}_2]^2[\text{H}_2]$
23. The reaction below represents the Haber process for the industrial production of ammonia.



The optimum conditions of temperature and pressure are chosen as a compromise between those that favour a high yield of ammonia and those that favour a fast rate of production. Economic considerations are also important.

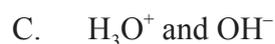
Which statement is correct?

- A. A higher temperature would ensure a higher yield and a faster rate.
- B. A lower pressure would ensure a higher yield at a lower cost.
- C. A lower temperature would ensure a higher yield and a faster rate.
- D. A higher pressure would ensure a higher yield at a higher cost.

24. Which combination of intermolecular forces, boiling point and enthalpy of vaporization is correct?

| | Intermolecular forces | Boiling point | Enthalpy of vaporization |
|----|-----------------------|---------------|--------------------------|
| A. | strong | low | low |
| B. | strong | high | low |
| C. | weak | low | high |
| D. | weak | low | low |

25. Which is **not** a conjugate acid-base pair?



26. The pH of a solution changes from pH = 2 to pH = 5. What happens to the concentration of the hydrogen ions during this pH change?

A. It decreases by a factor of 1000

B. It increases by a factor of 1000

C. It decreases by a factor of 100

D. It increases by a factor of 100

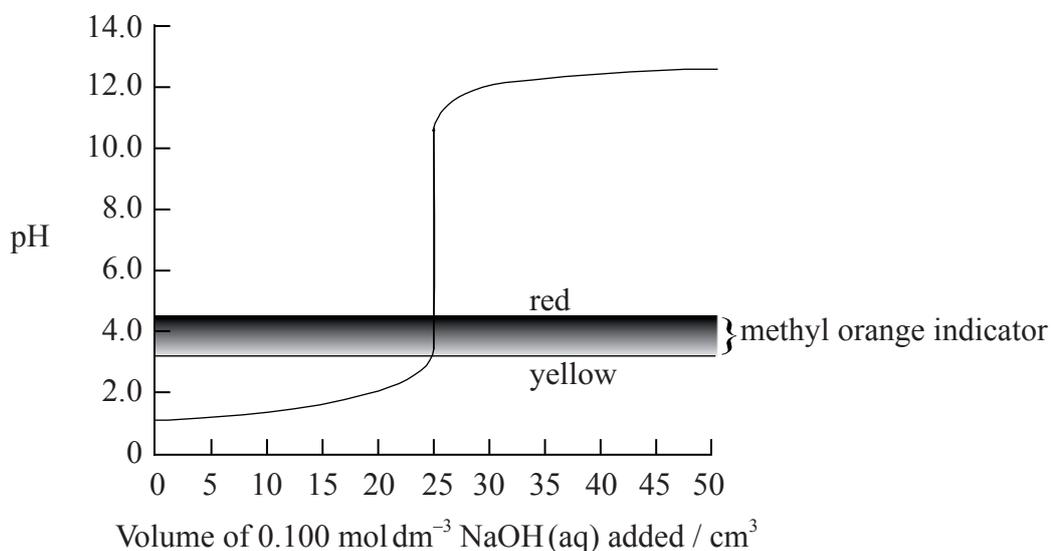
27. Based on information in the table below, which acid is the strongest?

| | Acid | pK_a | K_a |
|----|------|--------|--------------------|
| A. | HA | 2.0 | – |
| B. | HB | – | 1×10^{-3} |
| C. | HC | 4.0 | – |
| D. | HD | – | 1×10^{-5} |

28. Which combination will form a buffer solution?

- A. 100 cm³ of 0.10 mol dm⁻³ hydrochloric acid with 50 cm³ of 0.10 mol dm⁻³ sodium hydroxide.
- B. 100 cm³ of 0.10 mol dm⁻³ ethanoic acid with 50 cm³ of 0.10 mol dm⁻³ sodium hydroxide.
- C. 50 cm³ of 0.10 mol dm⁻³ hydrochloric acid with 100 cm³ of 0.10 mol dm⁻³ sodium hydroxide.
- D. 50 cm³ of 0.10 mol dm⁻³ ethanoic acid with 100 cm³ of 0.10 mol dm⁻³ sodium hydroxide.

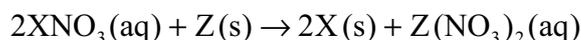
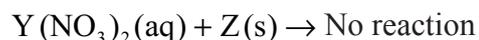
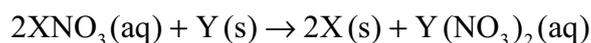
29. The graph below shows the titration curve of 25 cm³ of 0.100 mol dm⁻³ of hydrochloric acid with sodium hydroxide, of 0.100 mol dm⁻³ concentration. The indicator methyl orange was used to determine the equivalence point. Methyl orange has a pH range of 3.2–4.4.



If the hydrochloric acid was replaced by ethanoic acid of the same volume and concentration, which property of the titration would remain the same?

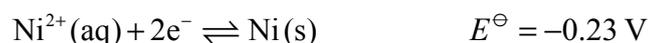
- A. The initial pH
 - B. The pH at the equivalence point
 - C. The volume of strong base, NaOH, needed to reach the equivalence point
 - D. The colour of the titration mixture just before the equivalence point is reached
30. What happens to iodine when iodate ions, IO₃⁻, are converted to iodine molecules, I₂?
- A. It undergoes reduction and its oxidation number changes from -1 to 0
 - B. It undergoes oxidation and its oxidation number changes from -1 to 0
 - C. It undergoes reduction and its oxidation number changes from +5 to 0
 - D. It undergoes oxidation and its oxidation number changes from +5 to 0

31. Consider the following reactions of three unknown metals X, Y and Z.



What is the order of **increasing** reactivity of the metals (least reactive first)?

- A. $\text{X} < \text{Y} < \text{Z}$
 B. $\text{X} < \text{Z} < \text{Y}$
 C. $\text{Z} < \text{Y} < \text{X}$
 D. $\text{Y} < \text{Z} < \text{X}$
32. The standard electrode potentials for two metals are given below.



What is the equation and cell potential for the spontaneous reaction that occurs?

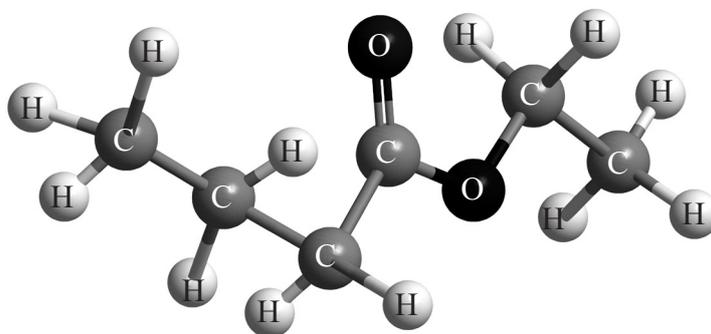
- A. $2\text{Al}^{3+}(\text{aq}) + 3\text{Ni}(\text{s}) \rightarrow 2\text{Al}(\text{s}) + 3\text{Ni}^{2+}(\text{aq}) \quad E^\ominus = 1.89 \text{ V}$
 B. $2\text{Al}(\text{s}) + 3\text{Ni}^{2+}(\text{aq}) \rightarrow 2\text{Al}^{3+}(\text{aq}) + 3\text{Ni}(\text{s}) \quad E^\ominus = 1.89 \text{ V}$
 C. $2\text{Al}^{3+}(\text{aq}) + 3\text{Ni}(\text{s}) \rightarrow 2\text{Al}(\text{s}) + 3\text{Ni}^{2+}(\text{aq}) \quad E^\ominus = 1.43 \text{ V}$
 D. $2\text{Al}(\text{s}) + 3\text{Ni}^{2+}(\text{aq}) \rightarrow 2\text{Al}^{3+}(\text{aq}) + 3\text{Ni}(\text{s}) \quad E^\ominus = 1.43 \text{ V}$
33. The same quantity of electricity was passed through separate molten samples of sodium bromide, NaBr, and magnesium chloride, MgCl₂. Which statement is true about the amounts, in mol, that are formed?
- A. The amount of Mg formed is equal to the amount of Na formed.
 B. The amount of Mg formed is equal to the amount of Cl₂ formed.
 C. The amount of Mg formed is twice the amount of Cl₂ formed.
 D. The amount of Mg formed is twice the amount of Na formed.

34. Which of the structures below is an aldehyde?
- A. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
 - B. $\text{CH}_3\text{CH}_2\text{COCH}_3$
 - C. $\text{CH}_3\text{CH}_2\text{COOCH}_3$
 - D. $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
35. Which type of reaction occurs when 2-iodo-2-methylpropane, $\text{C}(\text{CH}_3)_3\text{I}$, reacts with aqueous sodium hydroxide, $\text{NaOH}(\text{aq})$?
- A. Addition
 - B. Free-radical substitution
 - C. $\text{S}_{\text{N}}1$
 - D. $\text{S}_{\text{N}}2$
36. Halogenoalkanes can undergo $\text{S}_{\text{N}}1$ and $\text{S}_{\text{N}}2$ reactions with aqueous sodium hydroxide. Which halogenoalkane will react fastest with a 0.1 mol dm^{-3} solution of aqueous sodium hydroxide?
- A. 2-chloro-2-methylpropane
 - B. 2-iodo-2-methylpropane
 - C. 1-chlorobutane
 - D. 1-iodobutane

37. Propanitrile can be prepared by reacting bromoethane with potassium cyanide. Which statement is **not** correct about the reaction between bromoethane and potassium cyanide?

- A. The reaction is bi-molecular.
- B. The reaction follows the S_N2 mechanism.
- C. Homolytic fission occurs between the carbon-bromine bond in bromoethane.
- D. The cyanide ion, $:CN^-$, acts as a nucleophile.

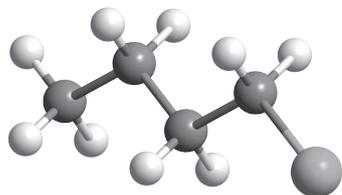
38. Which reactants could be used to form the compound below?



- A. Butanoic acid and ethanol
- B. Propanoic acid and ethanol
- C. Ethanoic acid and propan-1-ol
- D. Ethanoic acid and butan-1-ol

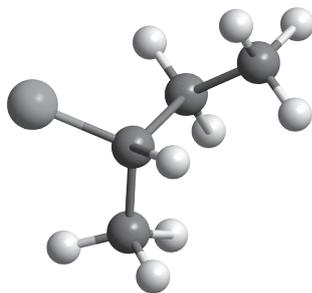
39. Which compound is optically active?

A.



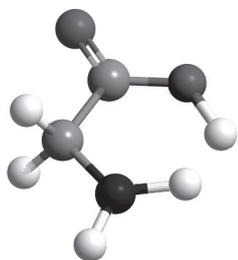
1-chlorobutane

B.



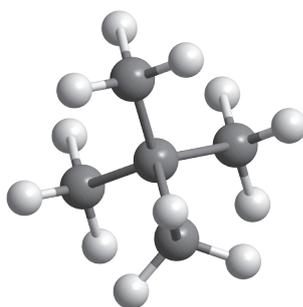
2-chlorobutane

C.



2-aminoethanoic acid

D.



2,2-dimethylpropane

40. A piece of metallic aluminium with a mass of 10.044 g was found to have a volume of 3.70 cm³. A student carried out the following calculation to determine the density.

$$\text{Density (g cm}^{-3}\text{)} = \frac{10.044}{3.70}$$

What is the best value the student could report for the density of aluminium?

- A. 2.715 g cm⁻³
- B. 2.7 g cm⁻³
- C. 2.71 g cm⁻³
- D. 2.7146 g cm⁻³