## CHEMISTRY <br> STANDARD LEVEL <br> PAPER 1

Friday 7 November 2003 (afternoon)
45 minutes

## 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.

| 1 | 2 |  |  |  |  | The Periodic Table |  |  |  |  |  | 3 | 4 | 5 | 6 | 7 | 0 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{gathered} 1 \\ \mathbf{H} \\ 1.01 \end{gathered}$ |  |  |  | Atomic Number <br> Element |  |  |  |  |  |  |  |  |  |  |  |  | $\begin{gathered} 2 \\ \mathbf{H e} \\ 4.00 \end{gathered}$ |
| $\begin{gathered} 3 \\ \mathbf{L i} \\ 6.94 \end{gathered}$ | $\begin{gathered} 4 \\ \mathbf{B e} \\ 9.01 \end{gathered}$ |  |  | Atomic Mass |  |  |  |  |  |  |  | $\begin{gathered} 5 \\ \mathbf{B} \\ 10.81 \end{gathered}$ | $\begin{gathered} { }^{6} \\ \mathbf{C} \\ 12.01 \end{gathered}$ | $\begin{gathered} 7 \\ \mathbf{N} \\ 14.01 \end{gathered}$ | $\begin{gathered} 8 \\ \mathbf{0} \\ 16.00 \end{gathered}$ | $\begin{gathered} 9 \\ \mathbf{F} \\ 19.00 \end{gathered}$ | $\begin{gathered} 10 \\ \mathbf{N e} \\ 20.18 \end{gathered}$ |
| $\begin{gathered} 11 \\ \mathbf{N a} \\ 22.99 \end{gathered}$ | $\begin{gathered} 12 \\ \mathbf{M g} \\ 24.31 \end{gathered}$ |  |  |  |  |  |  |  |  |  |  | $\begin{gathered} 13 \\ \mathbf{A l} \\ 26.98 \end{gathered}$ | $\begin{gathered} 14 \\ \mathbf{S i} \\ 28.09 \end{gathered}$ | $\begin{gathered} 15 \\ \mathbf{P} \\ 30.97 \end{gathered}$ | $\begin{gathered} 16 \\ \mathbf{S} \\ 32.06 \end{gathered}$ | $\begin{gathered} 17 \\ \mathbf{C l} \\ 35.45 \end{gathered}$ | $\begin{gathered} 18 \\ \mathbf{A r} \\ 39.95 \end{gathered}$ |
| $\begin{gathered} 19 \\ \mathbf{K} \\ 39.10 \end{gathered}$ | $\begin{gathered} 20 \\ \mathbf{C a} \\ 40.08 \end{gathered}$ | $\begin{gathered} 21 \\ \mathbf{S c} \\ 44.96 \end{gathered}$ | $\begin{gathered} 22 \\ \mathbf{T i} \\ 47.90 \end{gathered}$ | $\begin{gathered} 23 \\ \mathbf{V} \\ 50.94 \end{gathered}$ | $\begin{gathered} 24 \\ \mathbf{C r} \\ 52.00 \end{gathered}$ | $\begin{gathered} 25 \\ \mathbf{M n} \\ 54.94 \end{gathered}$ | $\begin{gathered} 26 \\ \mathbf{F e} \\ 55.85 \end{gathered}$ | $\begin{gathered} 27 \\ \text { Co } \\ 58.93 \end{gathered}$ | $\begin{gathered} 28 \\ \mathbf{N i} \\ 58.71 \end{gathered}$ | $\begin{gathered} 29 \\ \mathbf{C u} \\ 63.55 \end{gathered}$ | $\begin{gathered} 30 \\ \mathbf{Z n} \\ 65.37 \end{gathered}$ | $\begin{gathered} 31 \\ \mathbf{G a} \\ 69.72 \end{gathered}$ | $\begin{gathered} 32 \\ \mathbf{G e} \\ 72.59 \end{gathered}$ | $\begin{gathered} 33 \\ \text { As } \\ 74.92 \end{gathered}$ | $\begin{gathered} 34 \\ \mathrm{Se} \\ 78.96 \end{gathered}$ | $\begin{gathered} 35 \\ \mathbf{B r} \\ 79.90 \end{gathered}$ | $\begin{gathered} 36 \\ \mathbf{K r} \\ 83.80 \end{gathered}$ |
| $\begin{gathered} 37 \\ \mathbf{R b} \\ 85.47 \end{gathered}$ | $\begin{gathered} 38 \\ \mathbf{S r} \\ 87.62 \end{gathered}$ | $\begin{gathered} 39 \\ \mathbf{Y} \\ 88.91 \end{gathered}$ | $\begin{gathered} 40 \\ \mathbf{Z r} \\ 91.22 \end{gathered}$ | $\begin{gathered} 41 \\ \mathbf{N b} \\ 92.91 \end{gathered}$ | $\begin{gathered} 42 \\ \text { Mo } \\ 95.94 \end{gathered}$ | $\begin{gathered} 43 \\ \mathbf{T c} \\ 98.91 \end{gathered}$ | $\begin{gathered} 44 \\ \mathbf{R u} \\ 101.07 \end{gathered}$ | $\begin{array}{\|c} 45 \\ \mathbf{R h} \\ 102.91 \end{array}$ | $\begin{array}{\|c} 46 \\ \text { Pd } \\ 106.42 \end{array}$ | $\begin{array}{\|c} 47 \\ \mathbf{A g} \\ 107.87 \end{array}$ | $\begin{gathered} 48 \\ \mathbf{C d} \\ 112.40 \end{gathered}$ | $\begin{gathered} 49 \\ \text { In } \\ 114.82 \end{gathered}$ | $\begin{array}{\|c} 50 \\ \mathbf{S n} \\ 118.69 \end{array}$ | $\begin{gathered} 51 \\ \mathbf{S b} \\ 121.75 \end{gathered}$ | $\begin{array}{\|c} 52 \\ \mathbf{T e} \\ 127.60 \end{array}$ | $\begin{gathered} 53 \\ \text { I } \\ 126.90 \end{gathered}$ | $\begin{array}{\|c} 54 \\ \mathbf{X e} \\ 131.30 \end{array}$ |
| $\begin{gathered} 55 \\ \text { Cs } \\ 132.91 \end{gathered}$ | $\begin{gathered} 56 \\ \text { Ba } \\ 137.34 \end{gathered}$ | $\begin{gathered} 57 \dagger \\ \mathbf{L a} \\ 138.91 \end{gathered}$ | $\begin{gathered} 72 \\ \mathbf{H f} \\ 178.49 \end{gathered}$ | $\begin{gathered} 73 \\ \text { Ta } \\ 180.95 \end{gathered}$ | $\begin{gathered} 74 \\ \mathbf{W} \\ 183.85 \end{gathered}$ | $\begin{gathered} 75 \\ \mathbf{R e} \\ 186.21 \end{gathered}$ | $\begin{gathered} 76 \\ \mathbf{O s} \\ 190.21 \end{gathered}$ | $\begin{gathered} 77 \\ \mathbf{I r} \\ 192.22 \end{gathered}$ | $\begin{gathered} 78 \\ \mathbf{P t} \\ 195.09 \end{gathered}$ | $\begin{gathered} 79 \\ \mathbf{A u} \\ 196.97 \end{gathered}$ | $\begin{gathered} 80 \\ \mathbf{H g} \\ 200.59 \end{gathered}$ | $\begin{array}{\|c} 81 \\ \mathbf{T I} \\ 204.37 \end{array}$ | $\begin{gathered} 82 \\ \mathbf{P b} \\ 207.19 \end{gathered}$ | $\begin{gathered} 83 \\ \mathbf{B i} \\ 208.98 \end{gathered}$ | $\begin{gathered} 84 \\ \text { Po } \\ (210) \end{gathered}$ | $\begin{gathered} 85 \\ \mathbf{A t} \\ (210) \end{gathered}$ | $\begin{gathered} 86 \\ \mathbf{R n} \\ (222) \end{gathered}$ |
| $\begin{gathered} 87 \\ \mathbf{F r} \\ (223) \end{gathered}$ | $\begin{gathered} 88 \\ \mathbf{R a} \\ (226) \end{gathered}$ | $\begin{gathered} 89 \ddagger \\ \mathbf{A c} \\ (227) \end{gathered}$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| $\dagger$ |  |  | $\begin{gathered} 58 \\ \text { Ce } \\ 140.12 \end{gathered}$ | $\begin{gathered} 59 \\ \mathbf{P r} \\ 140.91 \end{gathered}$ | $\begin{gathered} 60 \\ \mathbf{N d} \\ 144.24 \end{gathered}$ | $\begin{gathered} 61 \\ \text { Pm } \\ 146.92 \end{gathered}$ | $\begin{gathered} 62 \\ \mathbf{S m} \\ 150.35 \end{gathered}$ | $\begin{gathered} 63 \\ \text { Eu } \\ 151.96 \end{gathered}$ | $\begin{gathered} 64 \\ \text { Gd } \\ 157.25 \end{gathered}$ | $\begin{gathered} 65 \\ \mathbf{T b} \\ 158.92 \end{gathered}$ | $\begin{gathered} 66 \\ \text { Dy } \\ 162.50 \end{gathered}$ | $\begin{array}{\|c\|} \hline 67 \\ \text { Ho } \\ 164.93 \end{array}$ | $\begin{gathered} 68 \\ \mathbf{E r} \\ 167.26 \end{gathered}$ | $\begin{gathered} 69 \\ \mathbf{T m} \\ 168.93 \end{gathered}$ | $\begin{gathered} 70 \\ \mathbf{Y b} \\ 173.04 \end{gathered}$ | $\begin{gathered} 71 \\ \mathbf{L u} \\ 174.97 \end{gathered}$ |  |
| $\pm$ |  |  | $\begin{gathered} 90 \\ \text { Th } \\ 232.04 \end{gathered}$ | $\begin{gathered} 91 \\ \mathbf{P a} \\ 231.04 \end{gathered}$ | $\begin{gathered} 92 \\ \mathbf{U} \\ 238.03 \end{gathered}$ | $\begin{gathered} 93 \\ \mathbf{N p} \\ (237) \end{gathered}$ | $\begin{gathered} 94 \\ \mathbf{P u} \\ (242) \end{gathered}$ | $\begin{gathered} 95 \\ \text { Am } \\ (243) \end{gathered}$ | $\begin{gathered} 96 \\ \mathbf{C m} \\ (247) \end{gathered}$ | $\begin{gathered} 97 \\ \text { Bk } \\ (247) \end{gathered}$ | $\begin{gathered} 98 \\ \text { Cf } \\ (251) \end{gathered}$ | $\begin{gathered} 99 \\ \text { Es } \\ (254) \end{gathered}$ | $\begin{gathered} 100 \\ \mathbf{F m} \\ (257) \end{gathered}$ | $\begin{gathered} 101 \\ \text { Md } \\ (258) \end{gathered}$ | $\begin{gathered} 102 \\ \text { No } \\ (259) \end{gathered}$ | $\begin{gathered} 103 \\ \mathbf{L r} \\ (260) \end{gathered}$ |  |

1. What amount (in moles) is present in 2.0 g of sodium hydroxide, NaOH ?
A. 0.050
B. 0.10
C. 20
D. 80
2. A hydrocarbon contains $90 \%$ by mass of carbon. What is its empirical formula?
A. $\mathrm{CH}_{2}$
B. $\mathrm{C}_{3} \mathrm{H}_{4}$
C. $\quad \mathrm{C}_{7} \mathrm{H}_{10}$
D. $\mathrm{C}_{9} \mathrm{H}_{10}$
3. Copper can react with nitric acid as follows.

$$
3 \mathrm{Cu}+{ }_{-} \mathrm{HNO}_{3} \rightarrow{ }_{-} \mathrm{Cu}\left(\mathrm{NO}_{3}\right)_{2}+{ }_{-} \mathrm{H}_{2} \mathrm{O}+{ }_{-} \mathrm{NO}
$$

What is the coefficient for $\mathrm{HNO}_{3}$ when the equation is balanced?
A. 4
B. 6
C. 8
D. 10
4. Lithium hydroxide reacts with carbon dioxide as follows.

$$
2 \mathrm{LiOH}+\mathrm{CO}_{2} \rightarrow \mathrm{Li}_{2} \mathrm{CO}_{3}+\mathrm{H}_{2} \mathrm{O}
$$

What mass (in grams) of lithium hydroxide is needed to react with 11 g of carbon dioxide?
A. 6
B. 12
C. 24
D. 48
5. What is the correct number of each particle in a fluoride ion, ${ }^{19} \mathrm{~F}^{-}$?

|  | protons | neutrons | electrons |
| :--- | :---: | :---: | :---: |
| A. | 9 | 10 | 8 |
| B. | 9 | 10 | 9 |
| C. | 9 | 10 | 10 |
| D. | 9 | 19 | 10 |
|  |  |  |  |

6. Which statement is correct for the emission spectrum of the hydrogen atom?
A. The lines converge at lower energies.
B. The lines are produced when electrons move from lower to higher energy levels.
C. The lines in the visible region involve electron transitions into the energy level closest to the nucleus.
D. The line corresponding to the greatest emission of energy is in the ultraviolet region.
7. Which of the following properties of the halogens increase from F to I?
I. Atomic radius
II. Melting point
III. Electronegativity
A. I only
B. I and II only
C. I and III only
D. I, II and III
8. Which pair would react together most vigorously?
A. Li and $\mathrm{Cl}_{2}$
B. Li and $\mathrm{Br}_{2}$
C. K and $\mathrm{Cl}_{2}$
D. K and $\mathrm{Br}_{2}$
9. Element $X$ is in group 2, and element $Y$ in group 7, of the periodic table. Which ions will be present in the compound formed when $X$ and $Y$ react together?
A. $\quad X^{+}$and $Y^{-}$
B. $X^{2+}$ and $Y^{-}$
C. $\quad X^{+}$and $Y^{2-}$
D. $\quad X^{2-}$ and $Y^{+}$
10. Which is the correct description of polarity in $\mathrm{F}_{2}$ and HF molecules?
A. Both molecules contain a polar bond.
B. Neither molecule contains a polar bond.
C. Both molecules are polar.
D. Only one of the molecules is polar.
11. Which types of bonding are present in $\mathrm{CH}_{3} \mathrm{CHO}$ in the liquid state?
I. Single covalent bonding
II. Double covalent bonding
III. Hydrogen bonding
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
12. Which statement(s) is/are generally true about the melting points of substances?
I. Melting points are higher for compounds containing ions than for compounds containing molecules.
II. A compound with a low melting point is less volatile than a compound with a high melting point.
III. The melting point of a compound is decreased by the presence of impurities.
A. I only
B. I and III only
C. II and III only
D. I, II and III
13. What change(s) occur(s) when a liquid boils?
I. The average energy of the particles increases.
II. The attractive forces between the particles become stronger.
III. The spacing between the particles increases.
A. I only
B. III only
C. II and III only
D. I and III only
14. Which change in conditions would increase the volume of a fixed mass of gas?
A.

| Pressure / kPa | Temperature / K |
| :---: | :---: |
| Doubled | Doubled |
| Halved | Halved |
| Doubled | Halved |
| Halved | Doubled |

15. Which statements about exothermic reactions are correct?
I. They have negative $\Delta H$ values.
II. The products have a lower enthalpy than the reactants.
III. The products are more energetically stable than the reactants.
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
16. A sample of a metal is heated. Which of the following are needed to calculate the heat absorbed by the sample?
I. The mass of the sample
II. The density of the sample
III. The specific heat capacity of the sample
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
17. The average bond enthalpies for $\mathrm{O}-\mathrm{O}$ and $\mathrm{O}=\mathrm{O}$ are 146 and $496 \mathrm{~kJ} \mathrm{~mol}^{-1}$ respectively. What is the enthalpy change, in kJ , for the reaction below?

$$
\mathrm{H}-\mathrm{O}-\mathrm{O}-\mathrm{H}(\mathrm{~g}) \rightarrow \mathrm{H}-\mathrm{O}-\mathrm{H}(\mathrm{~g})+\frac{1}{2} \mathrm{O}=\mathrm{O}(\mathrm{~g})
$$

A. -102
B. +102
C. +350
D. +394
18. Which reaction has the greatest positive entropy change?
A. $\quad \mathrm{CH}_{4}(\mathrm{~g})+1 \frac{1}{2} \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{CO}(\mathrm{g})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{g})$
B. $\quad \mathrm{CH}_{4}(\mathrm{~g})+1 \frac{1}{2} \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{CO}(\mathrm{g})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{l})$
C. $\quad \mathrm{CH}_{4}(\mathrm{~g})+2 \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{CO}_{2}(\mathrm{~g})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{g})$
D. $\quad \mathrm{CH}_{4}(\mathrm{~g})+2 \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{CO}_{2}(\mathrm{~g})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{l})$
19. Excess magnesium was added to a beaker of aqueous hydrochloric acid on a balance. A graph of the mass of the beaker and contents was plotted against time (line 1).


What change in the experiment could give line 2 ?
I. The same mass of magnesium but in smaller pieces
II. The same volume of a more concentrated solution of hydrochloric acid
III. A lower temperature
A. I only
B. II only
C. III only
D. None of the above
20. The rate of a reaction between two gases increases when the temperature is increased and a catalyst is added. Which statements are both correct for the effect of these changes on the reaction?
A.

| Increasing the temperature | Adding a catalyst |
| :--- | :--- |
| Collision frequency increases | Activation energy increases |
| Activation energy increases | Activation energy does not change |
| Activation energy does not change | Activation energy decreases |
| Activation energy increases | Collision frequency increases |

21. Which statement(s) is/are true for a mixture of ice and water at equilibrium?
I. The rates of melting and freezing are equal.
II. The amounts of ice and water are equal.
III. The same position of equilibrium can be reached by cooling water and heating ice.
A. I only
B. I and III only
C. II only
D. III only
22. What will happen to the position of equilibrium and the value of the equilibrium constant when the temperature is increased in the following reaction?

$$
\mathrm{Br}_{2}(\mathrm{~g})+\mathrm{Cl}_{2}(\mathrm{~g}) \rightleftharpoons 2 \mathrm{BrCl}(\mathrm{~g}) \quad \Delta H=+14 \mathrm{~kJ}
$$

|  | Position of equilibrium | Value of equilibrium constant |
| :--- | :---: | :---: |
| A. | Shifts towards the reactants | Decreases |
| B. | Shifts towards the reactants | Increases |
| C. | Shifts towards the products | Decreases |
| D. | Shifts towards the products | Increases |
|  |  |  |

23. Which of the following is/are formed when a metal oxide reacts with a dilute acid?
I. A metal salt
II. Water
III. Hydrogen gas
A. I only
B. I and II only
C. II and III only
D. I, II and III
24. Four aqueous solutions, I, II, III and IV, are listed below.
I. $\quad 0.100 \mathrm{~mol} \mathrm{dm}^{-3} \mathrm{HCl}$
II. $\quad 0.010 \mathrm{~mol} \mathrm{dm}^{-3} \mathrm{HCl}$
III. $\quad 0.100 \mathrm{~mol} \mathrm{dm}^{-3} \mathrm{NaOH}$
IV. $\quad 0.010 \mathrm{~mol} \mathrm{dm}^{-3} \mathrm{NaOH}$

What is the correct order of increasing pH of these solutions?
A. I, II, III, IV
B. I, II, IV, III
C. II, I, III, IV
D. II, I, IV, III
25. The oxidation number of chromium is the same in all the following compounds except
A. $\mathrm{Cr}(\mathrm{OH})_{3}$.
B. $\mathrm{Cr}_{2} \mathrm{O}_{3}$.
C. $\mathrm{Cr}_{2}\left(\mathrm{SO}_{4}\right)_{3}$.
D. $\mathrm{CrO}_{3}$.
26. Magnesium is a more reactive metal than copper. Which is the strongest oxidizing agent?
A. Mg
B. $\mathrm{Mg}^{2+}$
C. Cu
D. $\mathrm{Cu}^{2+}$
27. Which processes occur during the electrolysis of molten sodium chloride?
I. Sodium and chloride ions move through the electrolyte.
II. Electrons move through the external circuit.
III. Oxidation takes place at the positive electrode (anode).
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
28. Which substance(s) could be formed during the incomplete combustion of a hydrocarbon?
I. Carbon
II. Hydrogen
III. Carbon monoxide
A. I only
B. I and II only
C. I and III only
D. II and III only
29. Which formulas represent butane or its isomer?
I. $\mathrm{CH}_{3}\left(\mathrm{CH}_{2}\right)_{2} \mathrm{CH}_{3}$
II. $\mathrm{CH}_{3} \mathrm{CH}\left(\mathrm{CH}_{3}\right) \mathrm{CH}_{3}$
III. $\left(\mathrm{CH}_{3}\right)_{3} \mathrm{CH}$
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
30. Which compound can exist as optical isomers?
A. $\mathrm{CH}_{3} \mathrm{CHBrCH}_{3}$
B. $\mathrm{CH}_{2} \mathrm{BrCHBrCH}_{3}$
C. $\mathrm{CH}_{2} \mathrm{BrCHBrCH} \mathrm{H}_{2} \mathrm{Br}$
D. $\mathrm{CHBr}_{2} \mathrm{CHBrCHBr}_{2}$

