## CHEMISTRY

STANDARD LEVEL
PAPER 1
Wednesday 14 November 2007 (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.
- The periodic table is provided for reference on page 2 of this examination paper.
The Periodic Table

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

1. Which expression gives the amount (in mol) of a substance, if the mass is given in grams?
A. $\frac{\text { mass }}{\text { molar mass }}$
B. $\frac{\text { molar mass }}{\text { mass }}$
C. $\frac{1}{\text { molar mass }}$
D. mass $\times$ molar mass
2. What is the total number of atoms in 0.20 mol of propanone, $\mathrm{CH}_{3} \mathrm{COCH}_{3}$ ?
A. $1.2 \times 10^{22}$
B. $6.0 \times 10^{23}$
C. $1.2 \times 10^{24}$
D. $\quad 6.0 \times 10^{24}$


$$
\mathrm{C}_{3} \mathrm{H}_{4}+\mathrm{O}_{2} \rightarrow \text { _ }_{2}+{ }_{-} \mathrm{H}_{2} \mathrm{O}
$$

A. 2
B. 3
C. 4
D. 5
4. Ethyne, $\mathrm{C}_{2} \mathrm{H}_{2}$, reacts with oxygen according to the equation below. What volume of oxygen (in $\mathrm{dm}^{3}$ ) reacts with $0.40 \mathrm{dm}^{3}$ of $\mathrm{C}_{2} \mathrm{H}_{2}$ ?

$$
2 \mathrm{C}_{2} \mathrm{H}_{2}(\mathrm{~g})+5 \mathrm{O}_{2}(\mathrm{~g}) \rightarrow 4 \mathrm{CO}_{2}(\mathrm{~g})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{~g})
$$

A. 0.40
B. 0.80
C. 1.0
D. 2.0
5. What is the symbol for a species that contains 15 protons, 16 neutrons and 18 electrons?
A. $\quad{ }_{16}^{31} \mathrm{~S}$
B. ${ }_{16}^{31} \mathrm{~S}^{3-}$
C. ${ }_{15}^{33} \mathrm{P}^{-}$
D. ${ }_{15}^{31} \mathrm{P}^{3-}$
6. What is the electron arrangement of an $\mathrm{Al}^{3+}$ ion?
A. 2,8
B. 2,3
C. $2,8,3$
D. $2,8,8$
7. Which element is a transition metal?
A. Ca
B. Cr
C. Ge
D. Se
8. When $\mathrm{Na}, \mathrm{K}$, and Mg are arranged in increasing order of atomic radius (smallest first), which order is correct?
A. $\mathrm{Na}, \mathrm{K}, \mathrm{Mg}$
B. $\mathrm{Na}, \mathrm{Mg}, \mathrm{K}$
C. $\mathrm{K}, \mathrm{Mg}, \mathrm{Na}$
D. $\mathrm{Mg}, \mathrm{Na}, \mathrm{K}$
9. What is the formula for an ionic compound formed between an element, X , from group 2 and an element, Y, from group 6?
A. $X Y$
B. $X_{2} Y$
C. $\mathrm{XY}_{2}$
D. $X_{2} Y_{6}$
10. In the molecules $\mathrm{N}_{2} \mathrm{H}_{4}, \mathrm{~N}_{2} \mathrm{H}_{2}$, and $\mathrm{N}_{2}$, the nitrogen atoms are linked by single, double and triple bonds, respectively. When these molecules are arranged in increasing order of the lengths of their nitrogen to nitrogen bonds (shortest bond first) which order is correct?
A. $\mathrm{N}_{2} \mathrm{H}_{4}, \mathrm{~N}_{2}, \mathrm{~N}_{2} \mathrm{H}_{2}$
B. $\mathrm{N}_{2} \mathrm{H}_{4}, \mathrm{~N}_{2} \mathrm{H}_{2}, \mathrm{~N}_{2}$
C. $\mathrm{N}_{2} \mathrm{H}_{2}, \mathrm{~N}_{2}, \mathrm{~N}_{2} \mathrm{H}_{4}$
D. $\mathrm{N}_{2}, \mathrm{~N}_{2} \mathrm{H}_{2}, \mathrm{~N}_{2} \mathrm{H}_{4}$
11. The compounds listed have very similar molar masses. Which has the strongest intermolecular forces?
A. $\mathrm{CH}_{3} \mathrm{CHO}$
B. $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{OH}$
C. $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{~F}$
D. $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{CH}_{3}$
12. What is the shape of the $\mathrm{CO}_{3}^{2-}$ ion and the approximate $\mathrm{O}-\mathrm{C}-\mathrm{O}$ bond angle?
A. Linear, $180^{\circ}$
B. Trigonal planar, $90^{\circ}$
C. Trigonal planar, $120^{\circ}$
D. Pyramidal $109^{\circ}$
13. What change occurs to the distance between molecules and to their kinetic energy when a liquid becomes a gas at its boiling point?
A. The distances between molecules and their kinetic energies both increase greatly.
B. The distances between molecules increases but their kinetic energies remain the same.
C. The distances between the molecules and their kinetic energies both remain the same.
D. The distances remain the same but their kinetic energies increase.
14. What will happen to the volume of a fixed mass of gas if the pressure and the Kelvin temperature are both doubled?
A. It will remain the same.
B. It will be double its initial volume.
C. It will be one-half its initial volume.
D. It will be four times its initial volume.
15. According to the enthalpy level diagram below, what is the sign for $\Delta H$ and what term is used to refer to the reaction?

reaction progress
A.

| $\Delta H$ | reaction |
| :---: | :---: |
| positive | endothermic |
| negative | exothermic |
| positive | exothermic |
| negative | endothermic |

16. When 40 joules of heat are added to a sample of solid $\mathrm{H}_{2} \mathrm{O}$ at $-16.0^{\circ} \mathrm{C}$ the temperature increases to $-8.0^{\circ} \mathrm{C}$. What is the mass of the solid $\mathrm{H}_{2} \mathrm{O}$ sample?
[Specific heat capacity of $\mathrm{H}_{2} \mathrm{O}(\mathrm{s})=2.0 \mathrm{~J} \mathrm{~g}^{-1} \mathrm{~K}^{-1}$ ]
A. $\quad 2.5 \mathrm{~g}$
B. $\quad 5.0 \mathrm{~g}$
C. 10 g
D. $\quad 160 \mathrm{~g}$
17. The $\Delta H^{\ominus}$ values for the formation of two oxides of nitrogen are given below.

$$
\begin{aligned}
\frac{1}{2} \mathrm{~N}_{2}(\mathrm{~g})+\mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{NO}_{2}(\mathrm{~g}) & \Delta H^{\ominus}=-57 \mathrm{~kJ} \mathrm{~mol}^{-1} \\
\mathrm{~N}_{2}(\mathrm{~g})+2 \mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{N}_{2} \mathrm{O}_{4}(\mathrm{~g}) & \Delta H^{\ominus}=+9 \mathrm{~kJ} \mathrm{~mol}^{-1}
\end{aligned}
$$

Use these values to calculate $\Delta H^{\ominus}$ for the following reaction (in kJ ):

$$
2 \mathrm{NO}_{2}(\mathrm{~g}) \rightarrow \mathrm{N}_{2} \mathrm{O}_{4}(\mathrm{~g})
$$

A. -105
B. -48
C. +66
D. +123
18. The $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ values for a reaction are both negative. What will happen to the spontaneity of this reaction as the temperature is increased?
A. The reaction will become more spontaneous as the temperature is increased.
B. The reaction will become less spontaneous as the temperature is increased.
C. The reaction will remain spontaneous at all temperatures.
D. The reaction will remain non-spontaneous at any temperature.
19. Which statement is correct about the rate expression for a chemical reaction?
A. It can be determined from its chemical equation.
B. It can be predicted from the value of $\Delta H^{\ominus}$ for the reaction.
C. It can be calculated from the effect of temperature on the reaction.
D. It can be determined by measuring the change in concentration of a reactant or product over time.
20. Which changes increase the rate of a chemical reaction?
I. Increase in the concentration of an aqueous solution
II. Increase in particle size of the same mass of a solid reactant
III. Increase in the temperature of the reaction mixture
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
21. What is the equilibrium constant expression, $K_{\mathrm{c}}$, for the reaction below?

$$
\mathrm{N}_{2}(\mathrm{~g})+2 \mathrm{O}_{2}(\mathrm{~g}) \rightleftharpoons 2 \mathrm{NO}_{2}(\mathrm{~g})
$$

A. $K_{c}=\frac{\left[\mathrm{NO}_{2}\right]}{\left[\mathrm{N}_{2}\right]\left[\mathrm{O}_{2}\right]}$
B. $\quad K_{\mathrm{c}}=\frac{2\left[\mathrm{NO}_{2}\right]}{3\left[\mathrm{~N}_{2}\right]\left[\mathrm{O}_{2}\right]}$
C. $K_{\mathrm{c}}=\frac{\left[\mathrm{NO}_{2}\right]^{2}}{\left[\mathrm{~N}_{2}\right]\left[\mathrm{O}_{2}\right]^{2}}$
D. $K_{\mathrm{c}}=\frac{\left[\mathrm{NO}_{2}\right]^{2}}{\left[\mathrm{~N}_{2}\right]+\left[\mathrm{O}_{2}\right]^{2}}$
22. Sulfur dioxide and oxygen react to form sulfur trioxide according to the equilibrium.

$$
2 \mathrm{SO}_{2}(\mathrm{~g})+\mathrm{O}_{2}(\mathrm{~g}) \rightleftharpoons 2 \mathrm{SO}_{3}(\mathrm{~g})
$$

How is the amount of $\mathrm{SO}_{3}$ and the value of the equilibrium constant for the reaction affected by an increase in pressure?
A. The amount of $\mathrm{SO}_{3}$ and the value of the equilibrium constant both increase.
B. The amount of $\mathrm{SO}_{3}$ and the value of the equilibrium constant both decrease.
C. The amount of $\mathrm{SO}_{3}$ increases but the value of the equilibrium constant decreases.
D. The amount of $\mathrm{SO}_{3}$ increases but the value of the equilibrium constant does not change.
23. Which acids are strong?
I. $\mathrm{HCl}(\mathrm{aq})$
II. $\mathrm{HNO}_{3}(\mathrm{aq})$
III. $\mathrm{H}_{2} \mathrm{SO}_{4}(\mathrm{aq})$
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
24. The pH of a solution changes from $\mathrm{pH}=1$ to $\mathrm{pH}=3$. What happens to the $\left[\mathrm{H}^{+}\right]$during this pH change?
A. It increases by a factor of 100 .
B. It decreases by a factor of 100 .
C. It increases by a factor of 1000 .
D. It decreases by a factor of 1000 .
25. What happens to vanadium during the reaction $\mathrm{VO}^{2+}(\mathrm{aq}) \rightarrow \mathrm{VO}_{3}^{-}(\mathrm{aq})$ ?
A. It undergoes oxidation and its oxidation number changes from +4 to +5 .
B. It undergoes oxidation and its oxidation number changes from +2 to +4 .
C. It undergoes reduction and its oxidation number changes from +2 to -1 .
D. It undergoes reduction and its oxidation number changes from +4 to +2 .
26. What occurs during the electrolysis of a molten salt?
A. Electricity is produced by a spontaneous redox reaction.
B. Electricity is used to cause a non-spontaneous redox reaction to occur.
C. Electrons flow through the molten salt.
D. Electrons are removed from both ions of the molten salt.
27. Which statement is correct about an oxidizing agent in a chemical reaction?
A. It reacts with oxygen.
B. It reacts with $\mathrm{H}^{+}$ions.
C. It loses electrons.
D. It undergoes reduction.
28. Which formula represents an aldehyde?
A. $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{CHO}$
B. $\mathrm{CH}_{3} \mathrm{COCH}_{3}$
C. $\mathrm{CH}_{3} \mathrm{CH}_{2} \mathrm{COOH}$
D. $\mathrm{CH}_{3} \mathrm{COOCH}_{3}$
29. Which reactions can ethene undergo?
I. addition
II. esterification
III. polymerization
A. I and II only
B. I and III only
C. II and III only
D. I, II and III
30. Which amino acid can exist as optical isomers?
A.

B.

C.

D.


