※ 注意：請於試卷上「選擇題作答區」依序作答。

I. 單選題 (每題3分，答錯不倒扣)。(60%)

1. Which element is most abundant in both Earth's crust and in human body? What is the symbol for this element?
   (a) H (b) Fe (c) O (d) Ca
2. Consider the following reactions:
   $AgNO_3$ (aq) + Zn (s) → Ag (s) + $Zn(NO_3)_2$
   $Co(NO_3)_2$ (aq) + Zn (s) → No reaction
   $AgNO_3$ (aq) + Co (s) → $Co(NO_3)_2$ (aq) + Ag (s)
   Which is the correct order of increasing activity for these metals?
   (a) Ag < Zn < Co (b) Co < Ag < Zn (c) Co < Zn < Ag (d) Ag < Co < Zn
   (e) Zn < Co < Ag
3. The specific heat of liquid bromine is 0.226 J/g-K. How much heat (J) is required to raise the temperature of 10.0 mL of bromine from 25.00°C to 27.30°C? The density of liquid bromine: 3.12 g/mL.
   (a) 5.20 (b) 10.4 (c) 16.2 (d) 32.4 (e) 300
4. Which of the following contains the greatest percentage of nitrogen by mass?
   (a) NH_3 (b) NO_2 (c) N_2O (d) $C_6H_4N_3O_6$ (e) HCN
5. A 230-mL sample of a 0.275 M solution is left on a hot plate overnight; the following morning the solution is 1.10 M. What volume of solvent has evaporated from the 0.275 M solution?
   (a) 58.0 mL (b) 63.3 mL (c) 172 mL (d) 230 mL (e) 288 mL
6. When 0.72 g of a liquid is vaporized at 110 C and 0.967 atm, the gas occupies a volume of 0.559 L. The empirical formula of the gas is CH_2. What is the molecular formula of the gas?
   (a) CH_2 (b) C_2H_4 (c) C_3H_6 (d) C_4H_8 (e) none of these
7. The value of the equilibrium constant K depends on
   (I) the initial concentrations of the reactants.
   (II) the initial concentrations of the products.
   (III) the final concentrations of the reactants.
   (IV) the final concentrations of the products.
   (a) I, II (b) II, III (c) III, IV (d) It is dependent on three of the above. (e) none of these
8. The strong acid HA is added to water. Which of the following is the strongest base in the system?
   (a) HA (b) H_2O (c) H_3O^+ (d) A^- (e) H_2A

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9. The two salts AgX and AgY have very similar solubilities in water. The salt AgX is much more soluble in acid than is AgY. What can be said about the relative strengths of the acids HX and HY?
   (a) Nothing (b) HY is stronger than HX. (c) HX is stronger than HY.
   (d) The acids have equal strengths.
10. Choose the correct statement.
   (a) Exothermic reactions are always spontaneous.
   (b) Free energy is independent of temperature.
   (c) A reaction that exhibits a negative value of ΔS cannot be spontaneous.
   (d) At constant pressure and temperature, a decrease in free energy ensures an increase in the entropy of the system.
   (e) none of these
11. How many electrons are transferred in the following reaction?
   $SO_3^{2-}{}_{(aq)} + MnO_4^-{}_{(aq)} \rightarrow SO_4^{2-}{}_{(aq)} + Mn^{2+}{}_{(aq)}$
   (a) 2 (b) 3 (c) 4 (d) 6 (e) 10
12. Which of the following statements about quantum theory is *incorrect*?
   (a) The energy and position of an electron cannot be determined simultaneously.
   (b) Lower energy orbitals are filled with electrons before higher energy orbitals.
   (c) When filling orbitals of equal energy, two electrons will occupy the same orbital before filling a new orbital.
   (d) No two electrons can have the same four quantum numbers.
   (e) All of these are correct.
13. Choose the compound with the most ionic bond.
   (a) LiCl (b) KF (c) NaCl (d) LiF (e) KCl
14. The hybridization of Cl in ClF_2^+ is
   (a) sp (b) sp^2 (c) sp^3 (d) dsp^3 (e) d^2sp^3
15. Which of the following compounds has the highest boiling point?
   (a) CH_4 (b) H_2O (c) NH_3 (d) N_2 (e) He
16. Calculate the molality of C_2H_5OH in a water solution that is prepared by mixing 50.0 mL of C_2H_5OH with 100.0 mL of H_2O at 20°C. The density of the C_2H_5OH is 0.789 g/mL at 20°C.
   (a) 0.086 m (b) 0.094 m (c) 1.24 m (d) 8.56 m (e) none of these
17. Choose the element whose ion has the largest concentration inside a human cell.
   (a) Li (b) Na (c) K (d) Rb (e) Cs
18. For the process $X^-{}_{(g)} \rightarrow X^-{}_{(aq)}$, select the ion with the most negative value of ΔH.
   (a) F^- (b) Cl^- (c) Br^- (d) I^- (e) At^-

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19. The color of a transition metal complex results from:
(a) bending vibrations.(b) stretching vibrations.(c) transition of an electron between d orbitals. (d) transition of an electron between an s and a p orbital (e) nuclear magnetic resonance.

20. Which of the following types of compounds lacks an sp^2-hybridized carbon center?
(a) aldehydes (b) ketones (c) alcohols (d) alkenes (e) benzene

II. 計算題 (每題10分)。(40%)

1. One mole of a liquid is vaporized at its boiling point, 65° C and 1.00 atm. ΔH_{vap} for the liquid is 43.8 kJ/mol at 65° C.
(a) Calculate w. (in the unit of J) (5%)
(b) Calculate ΔE. (in the unit of kJ) (5%)

2. The oxidation of Cr^{3+} to CrO_4^{2-} can be accomplished using Ce^{4+} in a buffered solution. The following data were obtained:

Relative Initial Rate	$[Ce^{4+}]_0$	$[Ce^{3+}]_0$	$[Cr^{3+}]_0$
1	2.0×10^{-3}	1.0×10^{-2}	3.0×10^{-2}
2	4.0×10^{-3}	2.0×10^{-2}	3.0×10^{-2}
4	4.0×10^{-3}	1.0×10^{-2}	3.0×10^{-2}
16	8.0×10^{-3}	2.0×10^{-2}	6.0×10^{-2}

(a) Determine the order in the rate law of the species Ce^{4+}. (3%)
(b) Determine the order in the rate law of the species Ce^{3+}. (4%)
(c) Determine the order in the rate law of the species Cr^{3+}. (3%)

3. Consider an ionic compound C_xA_y where the anions (A) are in a body-centered cubic arrangement and the cations (C) are located in all of the faces of the cubic unit cell.
(a) What is the empirical formula of the salt? (3%)
(b) If the edge length of the unit cell is 5.00 x 10 cm and the molar masses of C and A are 50.0 g/mol and 100.0 g/mol, respectively, calculate the density of C_xA_y. (3%)
(c) If the ionic radius of A is 200 pm, estimate the ionic radius of C (in the unit of pm). (4%)

4. (a) The 3d electrons in $Co(NH_3)_6^{3+}$ are all paired but $Fe(H_2O)_6^{3+}$ has unpaired electrons (is paramagnetic). Explain. (5%)
(b) A sample of wood from an Egyptian mummy case gives a ^{14}C count of 9.4 cpm/gC (counts per minute per gram of carbon). How old is the wood? (The initial decay rate of ^{14}C is 15.3 cpm/gC, and its half-life is 5730 years.) (5%)

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