注意事項：1. 答案一律寫在答案紙上，否則不予計分。

2. 請標明題號依序作答，答錯不倒扣。

＊1. 至 21. 題為單選題，每題四分。22. 和 23. 題為計算題（需列出計算過程），每題八分。

1. For which gas do the molecules have the smallest average kinetic energy?
   a) He　　d) NH_3
   b) Cl_2　　e) all gases the same
   c) CH_4

2. Consider the following reaction:

   $$2HF(g) \rightleftharpoons H_2(g) + F_2(g) \quad (K = 1.00 \times 10^{-2})$$

   Given 1.00 mole of HF(g), 0.500 mole of H_2(g), and 0.750 mole of F_2(g) are mixed in a 5.00-L flask, determine the reaction quotient, Q, and the net direction to achieve equilibrium.
   a) $Q = 0.150$; the equilibrium shifts to the right.
   b) $Q = 0.375$; the equilibrium shifts to the left.
   c) $Q = 0.150$; the equilibrium shifts to the left.
   d) $Q = 0.375$; the equilibrium shifts to the right.

3. Given the reaction $A(g) + B(g) \rightleftharpoons C(g) + D(g)$. You have the gases A, B, C, and D at equilibrium. Upon adding gas A, the value of K:
   a) increases because by adding A, more products are made, increasing the product to reactant ratio.
   b) decreases because A is a reactant so the product to reactant ratio decreases.
   c) does not change because A does not figure into the product to reactant ratio.
   d) does not change as long as the temperature is constant.
   e) depends on whether the reaction is endothermic or exothermic.

4. Which of the following will not produce a buffered solution?
   a) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M HCl
   b) 100 mL of 0.1 M $NaHCO_3$ and 25 mL of 0.2 M HCl
   c) 100 mL of 0.1 M Na_2CO_3 and 75 mL of 0.2 M HCl
   d) 50 mL of 0.2 M Na_2CO_3 and 5 mL of 1.0 M HCl
   e) 100 mL of 0.1 M Na_2CO_3 and 50 mL of 0.1 M NaOH

5. In the titration of a weak acid HA with 0.100 M NaOH the stoichiometric point is known to occur at a pH value of approximately 10. Which of the following indicator acids would be best to use to mark the endpoint of this titration?
   a) indicator A, $K_a = 10^{-14}$　　c) indicator C, $K_a = 10^{-8}$
   b) indicator B, $K_a = 10^{-11}$　　d) indicator D, $K_a = 10^{-6}$

6. 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　　c) HX is stronger than HY.
   b) HY is stronger than HX.　　d) The acids have equal strengths.

7. In which case must a reaction be spontaneous at all temperatures?
   a) ΔH is positive, ΔS is positive.　　c) $\Delta S = 0$, ΔH is positive.
   b) $\Delta H = 0$, ΔS is negative.　　d) ΔH is negative, ΔS is positive.

（背面仍有題目，請繼續作答）

8. For the reaction $2HF(g) \rightleftharpoons H_2(g) + F_2(g)$, $\Delta G° = 38.3$ kJ, at 1000 K. If, at this temperature, 5.00 moles of HF(g), 0.500 moles of $H_2(g)$, and 0.75 moles of $F_2(g)$ are mixed in a 1.00-L container:
   a) Some HF will decompose (to yield H_2 and F_2).
   b) The system is at equilibrium.
   c) Some HF will be formed (from H_2 and F_2).
   d) Not enough data are given to answer this question.
9. Choose the correct statement given the following information:

$$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \qquad E° = 0.77 \text{ volt}$$
$$Fe(CN)_6^{3-} + e^- \rightarrow Fe(CN)_6^{4-} \qquad E° = 0.36 \text{ volt}$$

   a) $Fe^{2+}(aq)$ is more likely to be oxidized than Fe^{2+} complexed to CN^-.
   b) $Fe^{3+}(aq)$ is more likely to be reduced than Fe^{3+} complexed to CN^-.
   c) Both a and b are true.
   d) Complexation of Fe ions with CN^- has no effect on their tendencies to become oxidized or reduced.
10. For a reaction in a voltaic cell both $\Delta H°$ and $\Delta S°$ are positive. Which of the following statements is true?
   a) $E°_{cell}$ will increase with an increase in temperature.
   b) $E°_{cell}$ will decrease with an increase in temperature.
   c) $E°_{cell}$ will not change when the temperature increases.
   d) $\Delta G° > 0$ for all temperatures.
11. A cell is set up with copper and lead electrodes in contact with $CuSO_4(aq)$ and $Pb(NO_3)_2(aq)$, respectively, at 25°C. The standard reduction potentials are:

$$Pb^{2+} + 2e^- \rightarrow Pb \qquad E° = -0.13 \text{ V}$$
$$Cu^{2+} + 2e^- \rightarrow Cu \qquad E° = +0.34 \text{ V}$$

   If sulfuric acid is added to the $Pb(NO_3)_2$ solution, forming a precipitate of $PbSO_4$, the cell potential:
   a) increases　　c) is unchanged
   b) decreases　　d) can't tell what will happen
12. In which groups do all the elements have the same number of valence electrons?
   a) P, S, Cl　　d) P, As, Se
   b) Ag, Cd, Ar　　e) none
   c) Na, Ca, Ba
13. Place the elements C, N and O in order of increasing ionization energy.
   a) C, N, O　　c) C, O, N
   b) O, N, C　　d) N, O, C
14. Which of the following molecules has a dipole moment?
   a) CF_4　　c) XeF_4
   b) SF_4　　d) All of the above have a dipole moment.
15. Which of the following sets has elements with the most nearly identical atomic radii?
   a) Cr, Mn, Fe, Co　　d) Be, B, C, N
   b) Mg, Ca, Sr, Ba　　e) C, P, Se, I
   c) Ne, Ar, Kr, Xe
16. Which of the following is paramagnetic?
   a) B_2　　c) H_2
   b) C_2　　d) N_2

17. What is the hybridization of Cl in the molecule ClF_3?

a) sp　　d) dsp^3
b) sp^2　　e) d^2sp^3
c) sp^3

18. Which of the following is the correct order of boiling points for KNO_3, CH_3OH, C_2H_6, Ne?

a) $Ne < CH_3OH < C_2H_6 < KNO_3$　　c) $Ne < C_2H_6 < KNO_3 < CH_3OH$
b) $KNO_3 < CH_3OH < C_2H_6 < Ne$　　d) $Ne < C_2H_6 < CH_3OH < KNO_3$

19. A material is made from Al, Ga, and As. The mole fraction of each element is 0.25, 0.26, and 0.49, respectively. This material would be

a) a metallic conductor because Al is present.　　c) a *p*-type semiconductor.
b) an insulator.　　d) an *n*-type semiconductor.

20. Which of the following statements is true about the octahedral complexes of Ni^{2+}?

a) Both strong- and weak-field complexes are diamagnetic.
b) The strong-field complex is diamagnetic and the weak-field complex is paramagnetic.
c) The strong-field complex is paramagnetic and the weak-field complex is diamagnetic.
d) Both strong- and weak-field complexes are paramagnetic.

21. The spectrochemical series is

$$I^- < Br^- < Cl^- < F^- < OH^- < H_2O < NH_3 < en < NO_2^- < CN^-$$

Which of the following complexes will absorb visible radiation of the highest energy (shortest wavelength)?

a) $[Co(H_2O)_6]^{3+}$　　d) $[Co(en)_3]^{3+}$
b) $[Co(I)_6]^{3-}$　　e) $[Co(NH_3)_6]^{3+}$
c) $[Co(OH)_6]^{3-}$

22. At a certain temperature $K = 1.1 \times 10^3$ L/mol for the reaction

$$Fe^{3+}(aq) + SCN^-(aq) \rightleftharpoons FeSCN^{2+}(aq)$$

Calculate the concentrations of Fe^{3+}, SCN^-, and $FeSCN^{2+}$ at equilibrium if 0.020 mol of $Fe(NO_3)_3$ is added to 1.0 L of 0.10 *M* KSCN. (Neglect any volume change.)

23. Consider the following galvanic cell at 25°C:

$$Pt\,|\,Cr^{2+}(0.30\ M), Cr^{3+}(2.0\ M)\,||\,Co^{2+}(0.20\ M)\,|\,Co$$

The overall reaction and equilibrium constant value are

$$2Cr^{2+}(aq) + Co^{2+}(aq) \longrightarrow$$

$$2Cr^{3+}(aq) + Co(s) \quad K = 2.79 \times 10^7$$

Calculate the cell potential, $\mathscr{E}$, for this galvanic cell and ΔG for the cell reaction at these conditions.

(log 2.79 = 0.4456 ; log 2.22 = 0.3463)