

※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。
請將答案寫在答案卷上，並清楚標明題號。

一、選擇題(50%；每題 2%)

1. Which of the following pairs of compounds can be used to illustrate the law of multiple proportions?

- A) NH_3 and NBr_3 B) CaO and CaCl_2 C) H_2O and HI D) NO and NO_2
E) CH_4 and CO_2

2. Which of the following is true about an individual atom?

- A) An individual atom should be considered to be a liquid.
B) An individual atom should be considered to be a solid.
C) An individual atom should be considered to be a gas.
D) An individual atom can not be considered to be a liquid, solid, or gas.
E) The state of the atom depends on which element it is.

3. Which of the following solutions contains the greatest total ion concentration?

- A) One mole of potassium chloride dissolved in 1.0 L of solution.
B) One mole of iron(II) nitrate dissolved in 1.0 L of solution.
C) One mole of potassium hydroxide dissolved in 1.0 L of solution.
D) One mole of sodium phosphate dissolved in 1.0 L of solution.
E) At least two of these solutions have an equal number of ions, and these contain the greatest total ion concentration.

4. Under which of the following conditions does a gas behave most ideally?

- A) STP B) $P = 1.0 \text{ atm}$, $T = 100.0^\circ\text{C}$ C) $P = 0.50 \text{ atm}$, $T = 100.0^\circ\text{C}$
D) $P = 0.50 \text{ atm}$, $T = 0.0^\circ\text{C}$ E) $P = 2.0 \text{ atm}$, $T = -100.0^\circ\text{C}$

5. Which of the following statements is true?

- A) When two opposing processes are proceeding at identical rates, the system is at equilibrium.
B) Catalysts are an effective means of changing the position of an equilibrium.
C) The concentration of the products equals that of the reactants and is constant at equilibrium.
D) An endothermic reaction shifts toward reactants when heat is added to the reaction.
E) None of the above statements is true.

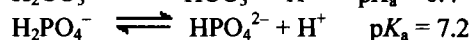
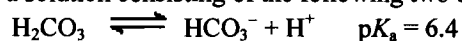
6. Which of the following species is *not* amphoteric?

- A) HSO_4^- B) H_2PO_4^- C) HPO_4^{2-} D) H_2O E) All of these are amphoteric.

7. Identify the strongest base.

- A) CH_3O^- B) CH_3OH C) CN^- D) H_2O E) NO_3^-

8. Consider a solution consisting of the following two buffer systems:

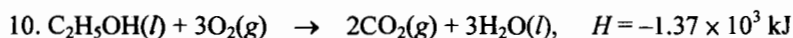


At pH 6.4, which one of the following is true of the relative amounts of acid and conjugate base present?

- A) $[\text{H}_2\text{CO}_3] > [\text{HCO}_3^-]$ and $[\text{H}_2\text{PO}_4^-] > [\text{HPO}_4^{2-}]$
B) $[\text{H}_2\text{CO}_3] = [\text{HCO}_3^-]$ and $[\text{H}_2\text{PO}_4^-] > [\text{HPO}_4^{2-}]$
C) $[\text{H}_2\text{CO}_3] = [\text{HCO}_3^-]$ and $[\text{HPO}_4^{2-}] > [\text{H}_2\text{PO}_4^-]$
D) $[\text{HCO}_3^-] > [\text{H}_2\text{CO}_3]$ and $[\text{HPO}_4^{2-}] > [\text{H}_2\text{PO}_4^-]$
E) $[\text{H}_2\text{CO}_3] > [\text{HCO}_3^-]$ and $[\text{HPO}_4^{2-}] > [\text{H}_2\text{PO}_4^-]$

9. Which of the following statements is correct?

- A) The internal energy of a system increases when more work is done by the system than heat is flowing into the system.
- B) The internal energy of a system decreases when work is done on the system and heat is flowing into the system.
- C) The system does work on the surroundings when an ideal gas expands against a constant external pressure.
- D) All the statements are true.
- E) All the statements are false.



For the combustion of ethyl alcohol as described in the above equation, which of the following statements is (are) true?

- I. The reaction is exothermic.
- II. The enthalpy change would be different if gaseous water were produced.
- III. The reaction is not an oxidation-reduction one.
- IV. The products of the reaction occupy a larger volume than the reactants.

- A) I, II B) I, II, III C) I, III, IV D) III, IV E) I only

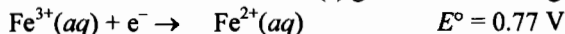
11. Consider the dissociation reaction of the acid HF.



Why is ΔS negative?

- A) Each HF molecule produces two ions when it dissociates.
- B) The ions are hydrated.
- C) The reaction is expected to be exothermic, and ΔS thus should be negative.
- D) The reaction is expected to be endothermic, and thus ΔS should be negative
- E) none of these

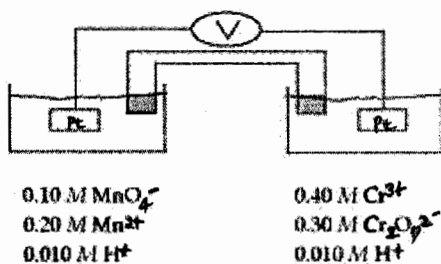
12. Choose the correct statement(s) given the following information:



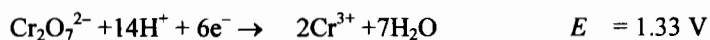
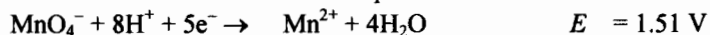
- I. $Fe^{2+}(aq)$ is more likely to be oxidized than Fe^{2+} complexed to CN^- .
- II. $Fe^{3+}(aq)$ is more likely to be reduced than Fe^{3+} complexed to CN^- .
- III. Complexation of Fe ions with CN^- has no effect on their tendencies to become oxidized or reduced.

- A) I only B) II only C) I and II D) III only E) None of these is true.

13. Refer to the galvanic cell below (the contents of each half-cell are written beneath each compartment).



The standard reduction potentials are as follows:



What is the value of E°_{cell} ?

- A) -0.18 V B) 2.84 V C) 0.18 V D) 1.79 V E) 2.29 V

14. From the following list of observations, choose the one that most clearly supports the conclusion that electrons have wave properties.

- A) the emission spectrum of hydrogen B) the scattering of alpha particles by metal foil
C) the photoelectric effect D) diffraction E) cathode "rays"

15. Choose the compound with the most ionic bond.

- A) LiF B) KF C) NaBr D) RbBr E) KBr

16. What is the hybridization of I in ICl_2^+ ?

- A) sp B) sp^2 C) sp^3 D) dsp^3 E) d^2sp^3

17. The following data were obtained for the reaction of NO with O_2 . Concentrations are in molecules/ cm^3 and rates are in molecules/ $\text{cm}^3 \cdot \text{s}$.

$[\text{NO}]_0$	$[\text{O}_2]_0$	Initial Rate
1×10^{18}	1×10^{18}	2.0×10^{16}
2×10^{18}	1×10^{18}	8.0×10^{16}
3×10^{18}	1×10^{18}	18.0×10^{16}
1×10^{18}	2×10^{18}	4.0×10^{16}
1×10^{18}	3×10^{18}	6.0×10^{16}

Which of the following is the correct rate law?

- A) $\text{Rate} = k[\text{NO}][\text{O}_2]$ B) $\text{Rate} = k[\text{NO}][\text{O}_2]^2$ C) $\text{Rate} = k[\text{NO}]^2[\text{O}_2]$ D) $\text{Rate} = k[\text{NO}]^2$
E) $\text{Rate} = k[\text{NO}]^2[\text{O}_2]^2$

18. For which order reaction is the half-life of the reaction independent of the initial concentration of the reactant(s)?

- A) zero order B) first order C) second order D) all of these E) none of these

19. Which of the following is the correct order of boiling points for NaNO_3 , $\text{C}_2\text{H}_5\text{OH}$, C_2H_6 , and Ne?

- A) $\text{Ne} < \text{C}_2\text{H}_5\text{OH} < \text{C}_2\text{H}_6 < \text{NaNO}_3$ B) $\text{NaNO}_3 < \text{C}_2\text{H}_5\text{OH} < \text{C}_2\text{H}_6 < \text{Ne}$
C) $\text{Ne} < \text{C}_2\text{H}_6 < \text{NaNO}_3 < \text{C}_2\text{H}_5\text{OH}$ D) $\text{Ne} < \text{C}_2\text{H}_6 < \text{C}_2\text{H}_5\text{OH} < \text{NaNO}_3$
E) $\text{C}_2\text{H}_6 < \text{Ne} < \text{C}_2\text{H}_5\text{OH} < \text{NaNO}_3$

20. Which of the following concentration measures will change in value as the temperature of a solution changes?

- A) mass percent B) mole fraction C) molality D) molarity
E) all of these

21. In which group are the elements listed in correct order of increasing first ionization energy?

- A) $\text{Na} > \text{P} > \text{Cl}$ B) $\text{Cs} > \text{Na} > \text{K}$ C) $\text{K} > \text{Ca} > \text{Ge}$ D) $\text{Cs} < \text{Rb} < \text{Na}$
E) $\text{Al} > \text{Si} > \text{P}$

22. Which metal ion has a d^6 electron configuration?

- A) Mn^{2+} B) Ni^{2+} C) Fe^{3+} D) Co^{3+} E) Ti^{2+}

23. Which types of processes are likely when the neutron-to-proton ratio in a nucleus is too large?

- I α decay II β decay III positron production IV electro capture
A) I, II B) II, III C) III, IV D) II only E) IV only

24. Which of the following names is a correct one?

- A) 3,4-dichloropentane B) 1-fluoro-2,4-methyl-3-propylcyclohexane
C) 1,1-dimethyl-2,2-diethylbutane D) *cis*-1,3-dimethylbutane E) 2-fluoro-1-chloro-4,4-dimethylnonane

25. Which of the following is *not* a structural isomer of 1-pentene?

- A) 2-pentene B) 2-methyl-2-butene C) cyclopentane
 D) 3-methyl-1-butene E) 1-methyl-cyclobutene

二、非選擇題 (50%)

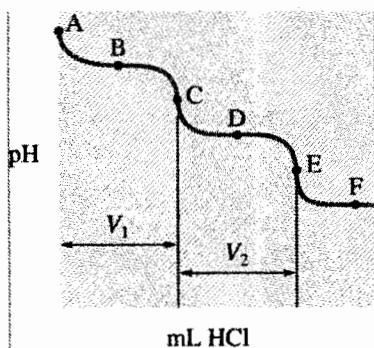
1. For the van der Waals equation, the constant a and b are the pressure correction and volume correction constants, respectively, for real gases. What is the available volume and pressure for the real gases, respectively. And why are the volume and pressure needed to be corrected? For real gasses, H_2 , N_2 , CH_4 , C_2H_6 , and C_3H_8 , which has the largest value of the van der Waals constant b ? (10%)

2. You need to make 150.0 ml of a 0.10 M NaCl solution. You have solid NaCl and your lab partner has a 2.5 M NaCl solution. Please show how to prepare a 0.10 M NaCl solution respectively from both the solid NaCl and the 2.5 M NaCl solutions. (6%)

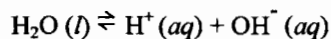
3. The titration of Na_2CO_3 with HCl has the following qualitative profile as shown below.

a. Identify the major species in solution as point A – E. (6%)

b. For the titration of 25 ml of 0.100 M Na_2CO_3 with 0.100 M HCl, calculate the pH at point B and D (B and D are half way points to equivalence. $K_{a1}: 4.3 \times 10^{-7}$; $K_{a2}: 4.8 \times 10^{-11}$) (4%)



4. a. Use the equation, $\Delta G^\circ = -RT \ln(K) = \Delta H^\circ - T\Delta S^\circ$, to determine ΔH° and ΔS° for the autoionization of water: (6%)



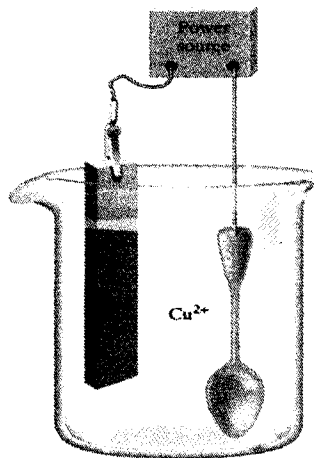
$T(^{\circ}C)$	K
0	1.14×10^{-15}
25	1.00×10^{-14}
35	2.09×10^{-14}
40	2.92×10^{-14}
50	5.47×10^{-14}

b. Estimate the value of ΔG° for the autoionization of water at its critical temperature, 374 °C. (4%)

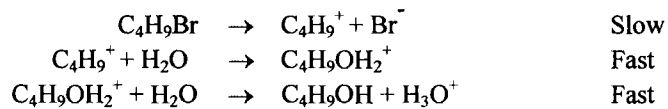
5. Copper can be plated onto a spoon by placing the spoon in an acidic solution of $\text{CuSO}_4(\text{aq})$ and connecting it to a copper strip via a power source as illustrated below.

a. Label the anode and cathode, and describe the direction of electron flow. (3%)

b. Write out the chemical equations for the reactions that occur at each electrode. (2%)



6. A propose mechanism for a reaction is:



Write the rate law expected for this mechanism. (3%)

What is the overall balanced equation for the reaction? (3%)

What are the intermediates in the proposed mechanism? (3%)