說明： 1．答案一律寫在試卷上，否則不予計分。
2．請依序作答、並標明題號，但不必抄題。
3．計算題必須寫出計算過程，否則不予計分。

一、選擇題：（40%，不倒扣，每題二分）

1 How many total protons are found in one molecule of Retinol ($C_{20}H_{30}O$) ?
    a. 30   b. 51   c. 151   d. 128   e. 158

2. The properties of the elements are a periodic function of
    a. atomic weight   b. neutron number   c. atomic number
    d. atomic size   e. density

3. Ionic crystals are
    a. good electricl conductors   b. low melting   c. soft
    d. nonbrittle   e. hard

4. Place the following species, O^{+2}, O^-, O^+, O, O^{-2}, in order of decreasing size.
    a. $O^{-2} > O^- > O^{+2} > O^+ > O$ b. $O^{+2} > O^+ > O > O^- > O^{-2}$
    c. $O^{-2} > O^- > O > O^+ > O^{+2}$ d. $O > O^{-2} > O^- > O^+ > O^{+2}$
    e. $O > O^{+2} > O^+ > O^- > O^{-2}$

5. How many electrons does element number 32 need to gain in order to attain the noble gas configuration ?
    a. 2   b. 6   c. 4   d. 1   e. 3

6. Molecules and complex ions are known to exhibit a square planar geometry. What hybridization describes this geometry ?
    a. sp^3 b. dsp^2 c. spd   d. sd^3 e. s^3p

7. Which of these plots will be not a stright line at constant T and n, for an ideal gas ?
    a. PV against P   b. V against P   c. PV against V
    d. P against 1/V   e. V against 1/P

8. What type of force or forces are known to exist between water molecules ?
    a. London forces   b. hydrogen bonds
    c. hydrogen bonds, London forces, and dipole-dipole forces
    d. hydrogen bonds, dipole-dipole forces   e. dipole-dipole forces

9. One of the following processes results in an increase in entropy. which process is it ?
    a. condensation   b. cooling of a gas   c. freezing
    d. cooling of a liquid   e. expansion of a gas

10. The first law of thermodynamics can be expressed mathematically as follow :
    a. $E = q - w$ b. $E = q + w$ c. $E = q \cdot w$
    d. $E = q / w$ e. $\Delta E = q + w$

11. In a second-order rate expression, what units must the specific rate constant possess ?
    a. M / t b. $1 / t$ c. $1 / M \cdot t$ d. t / M
    e. t / M^2

12. A catalyst has what effect at equilibrium ?
    a. speeds up the forward reaction   b. speeds up the backward reaction
    c. slows down the forward reaction   d. has no effect
    e. slows down the backward reaction

13. Which one of the following acids produces a strong conjugate base ?
   a. HI   b. HF   c. HBr   d. HNO_3 e. HCl

14. A buffer has the capacity to maintain a relative constant pH even with the addition of small amounts of strong acid or strong base and no change upon dilution. What substance or combination of substances act as a buffer ?
   a. KH_2PO_4 b. HCl and NaCl   c. HNO_2 and HNO_3
   d. KF and HF   e. KI and HI

15. What is the proper set of coefficients for the following equation ?

   __H_2S(g) + __H^+(aq) + __$[MnO4]^-$(aq) = __Mn^{2+}(aq) + __S(s) + __H_2O(l)

   a. 1, 1, 1, 1, 1, 1   b. 1, 2, 3, 3, 2, 1   c. 5, 6, 2, 2, 5, 8
   d. 2, 4, 3, 5, 2, 1   e. 8, 5, 3, 2, 5, 6

16. What type of bonding is used as a basis of crystal field theory ?
   a. covalent   b. ionic (electrostatic)   c. dipole-dipole
   d. hydrogen   e. ion-dipole

17. The positron is related to one of the stable fundamental subatomic particles. Which one of the following particles is related to positron ?
   a. proton   b. electron   c. neutrino   d. neutron   e. quark

18. The bond between the carbon atoms in acetylene (HCCH) consists of
   a. 6 pi electrons   b. 4 pi and 2 sigma electrons   c. 6 sigma electrons
   d. 2 pi and 4 sigma electrons   e. 3 pi and 3 sigma electrons

19. Acetic acid (CH_3COOH) is known to react with many compounds. Which one of the following compounds will not react with acetic acid ?
   a. CH_3OH b. NH_3 c. $CH4$ d. CH_3NH_2 e. NaOH

20. What is the number of possible isomers for C_4H_8 ?
   a. 3   b. 4   c. 6   d. 2   e. 5

二、問答與計算：（60%）

1. For the value of van der Waals constant a and b of $(P + n^2a/V^2)(V-nb) = nRT$, please answer the following questions. (8%)

   a). What are the physical interpretation (meaning) for larger values of a and b ?
   b). For a given real gas, as the pressure decreases and temperature increases, then what are a and b going to be ?

2. For the phase diagram of pure substance, such as water, please see the phase diagram shown below and answer the following questions. (8%)

   a). At a constant temperature T smaller than the triple point, then how can the liquid be made from the solid
   b). For this diagram, the liquid-solid line has a negative slope. What property of the water causes this unusual slope of curve ?
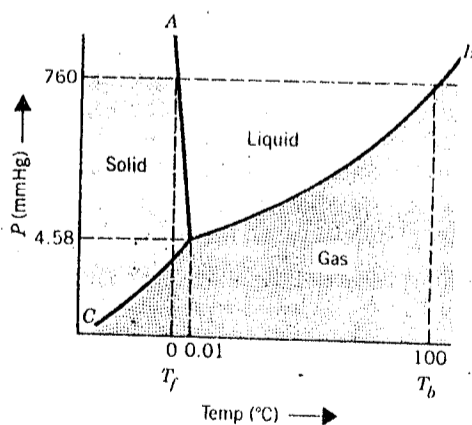
（背面仍有題目,請繼續作答）

3. What are called colligative properties ? Please list four colligative properties. (8%)

4. Please write the all orbitals associated with the principal quantum number $n = 3$? (8%)

5. Calculate the molality of 34.5% (by mass) aqueous solution of phosphoric acid (H_3PO_4). The molar mass of phosphoric acid is 98.00 g. (6%)

6. What is a spontaneous process ? What factors must we take into account to predict the spontaneity of a process ? (6%)

7. Calculate the pH of a mixture of 50.0 ml of 0.100 M CH_3COOH and 50.0 ml of 0.100 M NaOH. The Ka of CH_3COOH is 1.75×10^{-5}. (8%)

8. Give the valence electronic configuration and the number of unpaired electrons for the following two molecules. Please indicate which one is diamagnetic. (8%)

      a. CO   b. CN