※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。
化學共 50 題選擇題，每題答對得 2 分，答錯倒扣 0.5 分；滿分 100 分，倒扣至 0 分為止。

1. Which one of the following compounds you expect the smallest dissociation energy? (a) LiF (b) NaCl (c) KBr (d) KF (e) NaF

2. Methanol $CH_3OH$ can be produced by combining $H_2$ and CO. The percent yield of $CH_3OH$ is 51.8% and weights $3.57 \times 10^4$ g. The reactant CO is 68.5 kg. What is the weight of $H_2$? (a) 8.60 kg (b) 9.78 kg (c) 4.46 kg (d) 4.89 kg (e) 1.15 kg

3. Which one of the following processes is a spontaneous process with $\Delta S_0 > 0$? (a) KBr dissolves in water and the solution gets colder (b) Combusting propane, $C_3H_{8(g)} + 5O_{2(g)} \rightarrow 4H_2O_{(g)} + 3CO_{2(g)}$ $\Delta H = -2221$ kJ (c) Water is boiling in a teakettle (d) $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$ in a fuel cell battery (e) Photosynthetic process $6CO_{2(g)} + 6H_2O_{(l)} \rightarrow C_6H_{12}O_6 + 6O_{2(s)}$ in green plants

4. For real gases, we can approximate their non-ideal behaviors by van der Waals fluid equation, $[P + a(n/V)^2](V - nb) = nRT$, a and b are constants. After applying pressure onto the piston, for methane, ethane, propane, butane, and pentane with the same n moles, which gas do you expect to see condensation first? (a) Methane (b) Ethane (c) Propane (d) Butane (e) Pentane

5. For a molecular potential curve, (a) it is a graph that shows how the potential energy of a pair of molecules changes with the distance between their centers. (b) it is much deeper for nonbonding interactions than that related to bonding interactions. (c) the dissociation energy is slightly larger than the value indicated by the well depth. (d) the curve minimum is independent to the polarization of bonded atoms.

6. How many milliliters of 0.200 M $NH_4OH$ are needed to react with 12.0 mL of 0.550 M $FeCl_3$? $FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3 + 3NH_4Cl$　(a) 99.0 mL　(b) 33.0 mL (c) 8.25 mL　(d) 68.8 mL

7. Consider the flask diagramed below. What is the partial pressure of $N_2$ after the stopcock between the two flasks is opened? (a) 300, (b) 45, (c) 50.7, (d) 368, (e) 90 torr.



$N_2$, 1L, 0.2 atm

$H_2$, 2L, 475 torr
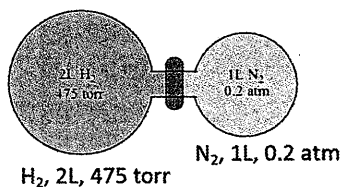
8. Which is the strongest halogen acid? (a) HF, (b) HCl, (c) HBr, (d) HI, (e) same acidity strength.

9. $CH_3CH_2COCH_3$ (methyl ethyl ketone), peak number in $^1$H-NMR spectrum is (a) 3:2:3, (b) 1:1:1, (c) 3:1:3, (d) 3:4:1, (e) 3:4:3.

10. Which of the following alcohol is less soluble in water? (a) Butanol (b) Propanol (c) Heptanol (d) Ethanol (e) Methanol

11. What is the molality of a solution made by dissolving 2.3 g of tolune ($C_7H_8$) in 500 g of benzene ($C_6H_6$)? Hint: molality (m) is defined as the number of moles of solutes in a kilogram of solvent. (a) 0.05 m. (b) 5 m. (c) 0.15 m. (d) 3 m. (e) 0.004 m.

12. How many structural and geometric (*cis-trans*) isomers will you expect for $C_3H_5Cl$? (a) 3 (b) 4 (c) 5 (d) 2 (e)6

13. Which of the following has the largest $k_b$ value? (a)Ammonia (b)Methlyamine (c)Ethylamine (d)Pyridine (e) Alcohol

14. Which one is NOT a spontaneous process? (a) corrosion (b) metal melting with the increase of heat absorption (c) purification of sea water (d) air pollution in a city (e) formation of ioxins and dioxin-like compounds

15. For the following descriptions of enthalpy or entropy, which one is NOT correct? (a) The magnitude of $\Delta H$ is directly proportional to the quantities of reactants and products in a reaction (b) Hess's law can be used to reduce the steps of overall reaction (c) If a reaction is reversed, the sign of $\Delta H$ is also reversed (d) Entropy is a not state function (e) In statistical mechanics, entropy is an extensive property of a thermodynamic system

16. Consider the following pairs of liquids. Which pairs are miscible?　1. benzene, $C_6H_6$, and hexane, $C_6H_{12}$ 2. water and methanol, $CH_3OH$　3. water and hexane　(a) 1, 2 only (b) 2 only　(c) 1 only (d) 2, 3 only

17. For the acid-based titration, (a) it is an example of volumetric analysis. (b) it is to determine the concentration of titrant. (c) it is to determine the exact reaction between titrant and substance. (d) the stoichiometric point is reached as the indicator has been completely consumed.

18. For binary compounds, which of the following descriptions is wrong? (a)The cation is always named first, and the anion second. (b) A monatomic cation takes its name from the name of element. (c) A monoatomic anion is named by taking the first part of the element name and adding –ide. (d) The NaCl is named sodium chlorine.

19. The hybridization of atomic orbitals for nitrogen in $NO_2^+$, $NO_3^-$, and $NH_4^+$ are? (a) $sp^2$, $sp^3$, and $sp^3$ (b) $sp^2$, $sp^3$, and $sp^2$ (c) sp, $sp^2$, and $sp^3$ (d) sp, $sp^3$, and $sp^2$ (e) $sp^3$, sp, and $sp^2$ respectively

20. Given $G = H - TS$, G, T, H and S denote free energy, temperature, system enthalpy, and entropy. Which following situation will give a spontaneous process for the system at constant pressure and temperature? (a) heat flows out of the system and $\Delta S < 0$ (b) heat flows in the system and $\Delta S < 0$ (c) heat flows out of the system and $\Delta S > 0$ (d) heat flows in the system and $\Delta S > 0$ (e) $\Delta G > 0$

21. Calculate formal charge of the following atoms.
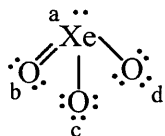


a, b, c, d= (a) 1,0,0,-1, (b) 2, 0, 1, 1, (c) 1, 0, -1, 0, (d) 2, 0, -1, -1, (e) 1, 0, -1, -1.

22. Liquid water turns to ice. This process is (a) endothermic, (b) exothermic, (c) catalytic, (d) excited, (e) decomposed.

23. Calculate the $K_{sp}$ value for $Ag_3PO_4$, which has a solubility of $1.6 \times 10^{-5}$ mol/L. (a) $7.7 \times 10^{-10}$ (b) $1.8 \times 10^{-18}$ (c)$6.6 \times 10^{-20}$ (d) $1.6 \times 10^{-19}$ (e) $3.0 \times 10^{-19}$

24. How much energy required to convert 100 g of ice at $-10°C$ to steam at $150°C$? Specific heat capacities for ice, water, and steam are $2.1 \ J \ g^{-1} \ °C^{-1}$, $4.2 \ J \ g^{-1} \ °C^{-1}$, and $2.0 \ J \ g^{-1} \ °C^{-1}$, respectively. The enthalpies of fusion and evaporation are 6.01 kJ/mol and 40.7 kJ/mol, respectively. (a) 272 KJ (b) 314 KJ (c) 88 KJ (d) 280 KJ (e) 238 KJ

25. A flashbulb of volume 2 cm$^3$ contains $O_2$ gas at pressure of 2 atm and a temperature of 27 °C. How many m.moles of $O_2$ gas in the flashbulb? Hint: Gas constant R = 0.08 [(L-atm)/(K-Mole)]. (a) 0.17. (b) 1.7. (c) 17. (d) 170. (e) 0.017.

26. The equilibrium K values for the Ammonia synthesis reaction are 90, 3, and 0.3, respectively, at 500K, 600K, and 700K. Which of the following statements is correct? (a)the synthesis reaction is endothermic (b)the synthesis reaction is exothermic (c)the process should be conducted at higher temperature to favor the reaction (d) temperature is irrelevant to the fraction of production (e)the process should be conducted under warm bath to enable the reaction

27. Aldehydes and ketones contain (a) amides (b) carboxylic acid (c) carbonyl (d) methyl (e) hydrocarbon group

28. For the concept of oxidation states, which of the following descriptions is wrong? (a) The oxidation state of an atom in an element is 0. (b) The oxidation state of a monatomic ion is the same as its charge. (c)In binary compounds, the element with the greater attraction for the electrons in the bond is assigned as a positive oxidation state. (d) In its covalent compounds with nonmetals, oxygen is assigned an oxidation state of -2, and the exception to this rule occurs in peroxides.

29. An unknown organic compound reacts with 576 g of air. After fully consuming the organic compound, the detected gases are 448 g $N_2$, 32 g $O_2$, 88 g of $CO_2$, and 54 g $H_2O$ are produced. Please find the organic compound (a) $CH_4$ (b) $C_2H_2$ (c) $C_3H_8$ (d) $C_2H_6$ (e) $C_2H_5OH$

30. Which of the following has the highest solubility in water? (a) $CH_3CH_2OH$ (b) $CCl_4$ (c) $CH_3(CH_2)_{14}CH_2OH$ (d) $CH_3CH_2CH_3$ (e) $CH_3CH_2CH_2CH_3$

31. How many atoms are in a body-centered-cubic (BCC) unit cell? Iron is crystallized in a form of α–iron, which has a BCC unit cell. Please calculate its density. Hint: lattice constant and mass of iron: 3 Å and 56 g/mole, respectively. (a) 2 and 6.9 g/cm$^3$. (b) 1 and 14.0 g/cm$^3$. (c) 4 and 1.0 g/cm$^3$. (d) 3 and 0.7 g/cm$^3$. (e) 5 and 30.0 g/cm$^3$.

32. Which of the followings is not a structural isomer for $C_8H_{18}$? (a)2-Methlyheptane (b)2,2-Dimethylhexane (c)2,2,4-Trimethylpentane (d)3,3-Dimethylheptane (e)2,2,3,3-Tetramethylbutane

33. Calcium has a cubic closest packed structure as a solid. Assuming that calcium has an atomic radius of 197 pm, what is the density (g/cm$^3$) of solid calcium? (a)2.00 (b)0.77 (c)1.54 (d)2.54 (e)2.31

34. For the following descriptions of buffered solutions, which one is NOT correct? (a) an application of acid-base solution (b) resistance to a pH change when either hydroxide ions or protons are added (c) like human blood, to absorb the acids and bases (d) a strong acid and its salt or a strong base and its salt (e) an aqueous solution consisting of a mixture of a weak acid and its conjugate base

35. The correct magnitude sequence of electronegativity is, (a) Li > Be > Na > K (b) Na > Be > C > Li (c) Be < Na < Mg < K (d) Li < Be < C < O (e) C < O < Be < Li

36. All of the following properties of the alkaline earth metals increase going down the group except (a) atomic radius (b) first ionization energy (c) ionic radius (d) atomic mass

37. What is the molality of a solution labeled "8.6% glucose (C6H12O6) by weight?" (Note: If the question does not give the solvent, assume it is water.) (a) 0.26 m (b) 0.34 m (c) 0.44 m (d) 0.52 m

38. Within the $BF_4^-$ molecule, (a) four common single covalent bonds are formed. (b) the octet of F atom is not complete even with the shared electron provided by Boron. (c) the octet of Boron is complete by sharing three electrons of Boron during the formation of single bonds. (d) both bonding electrons for each single bond are provided by the fluoride ion.

39. Carbon-14 dating is a commonly used technique to determine era of ancient articles made of wood or cloth. $^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e$ with a 5730-year half-life. The β decay rate of $^{14}_{6}C$ in freshly cut wood is 13.6 counts per minute per gram of carbon. The decay rate of $^{14}_{6}C$ in an ancient scroll is found 3.4 counts per minute per gram of carbon. Given $\ln 2 = 0.693$, approximate how many years age was the ancient scroll made? (a) 22920 (b) 11460 (c) 5730 (d) 2865 (e) 1432 years

40. In the electronic configurations of boron, carbon, nitrogen, oxygen, and fluorine, which one do you expect to have the strongest instability to form -1 valent anion? (a) Boron (b) Carbon (c) Nitrogen (d)

Oxygen (e) Fluorine

41. For the interactions between ions, (a) the strong electrostatic interactions between ions account for the typical properties of ionic solids, such as brittleness and high melting points. (b) it decays with the square of the distance between the centers of two ions. (c) they are stronger within KCl crystals than within CaO crystals. (d) they are responsible to cause ionic crystals not dissolvable in water.

42. Considering the resonance feature of molecules, (a) low-energy structures contribute more to the resonance mixture than high-energy structures. (b) structures with the same energy contribute differently to the resonance. (c) the nuclei move slightly in each contributing structure following the delocalization of electrons. (d) only long pairs of electrons are delocalized, and bonded electrons are not able to distribute over the whole molecules.

43. The limiting reagent in a chemical reaction is one that: (a) has the largest molar mass (formula weight). (b) has the smallest molar mass (formula weight). (c) has the smallest coefficient. (d) is consumed completely.

44. Which statement is wrong? (a) The atomic weight of carbon is about 12. (b) The most stable ion of lithium is $Li^+$. (c) A phosphorus atom is larger than an antimony atom. (d) The radius of a sodium atom is larger than that of a sodium cation.

45. What is the electronic configuration of Mn (Atomic number 25, VIIA)? (a) $[Ar]3d^5 4s^2$ (b) $[Ar]3d^7$ (c) $[Ar]3d^6 4s^1$ (d) $[Ar]4s^2$ (e) $[Ar]3p^2 3d^4 4s^2$

46. Brønsted and Lowry defined "An acid is a proton donor, a base is a proton acceptor", which is usually the concept of (a) acid-base titrations (b) oxidation-reduction reactions (c) balancing oxidation-reduction equations (d) acid-base reactions (e) Hume-Rothery rules

47. For the enthalpy change $\Delta H$ and the entropy change $\Delta S$ of a process, a spontaneous result for all temperatures will occur when (a) $\Delta S > 0, \Delta H < 0$ (b) $\Delta S > 0, \Delta H > 0$ (c) $\Delta S < 0, \Delta H < 0$ (d) $\Delta S < 0, \Delta H > 0$ (e) $\Delta S = 0, \Delta H = 0$

48. Which of the following solutions would have the highest vapor pressure at 28°C? (a) 0.010 $m$ $Na_3PO_4$ in water (b) 0.020 $m$ $CaBr_2$ in water (c) 0.020 $m$ KCl in water (d) 0.020 $m$ HF in water (e) 0.020 $m$ $CaCO_3$ in water

49. Which substance, AgCl, $Cl_2$, $P_4O_{10}$, and $I_2$, is most likely to exist as a gas at room temperature and normal atmosphere? (a) AgCl. (b) $P_4O_{10}$. (c) $Cl_2$. (d) $I_2$. (e) None of them.

50. Consider the reaction: Energy+$N_2O_4(g)$ $\rightleftharpoons$ 2$NO_2(g)$, which of the following can cause this reaction shift from left to right? (a) decrease in temperature (b) increase in container volume (c) addition of Argon (d) removal of $N_2O_4$ (e) Addition of $NO_2$.