● 本B科目試題含普通化學(第1～30題)、熱力學(第31～60題)、有機化學(第61～90題)三科目之試題，計90題，每一題為4選1，每一題答對得1分，答錯倒扣0.25分，未作答者不給分亦不扣分，滿分為90分。

1. Which of the following formula is correct?
   (a) O-C-O, (b) O=C=O, (c) H-N-H-H, (d) H-C=O
2. Which of the followings is a correct formula for ionic compound?
   (a) NaK, (b) $CaNa_2$, (c) Li_3N, (d) HF
3. A mass spectrum shows 6909 relative number of atoms at the mass number of 63, and 3091 at 65. The average mass of the investigated copper is (a) 63.55, (b) 65.55, (c) 60.00, (d) 63.00
4. Impure nickel can be purified by first forming the compound $Ni(CO)_4$, which is then decomposed by heating to yield very pure nickel. Metallic nickel reacts directly with gaseous carbon monoxide as follows:
   $Ni(s) + 4\ CO(g) \rightarrow Ni(CO)_4(g)$
   Other metals present do not react. If 94.2 g of a metal mixture produces 98.4 g of $Ni(CO)_4$, what is the mass percent of nickel in the original sample? (Ni: 58.69)
   (a)20%, (b)35.9%, (c) 45%, (d) 40.9%
5. Which of the following can be regarded as a strong electrolyte?
   (a) C_6H_6, (b) $CH_2=CH_2$, (c) HCl, (d) Protein

6. Precipitation may be observed in which of the following solution?
   (a) $NaNO_3$ + water + NaCl, (b) NH_4Cl + water + NaOH, (c) $AgNO_3$ + water + NaCl, (d) CH_3COONa + water + Sucrose
7. The volume of a 0.100 M HCl solution needed to neutralize 25.0 ml of a 0.350 M NaOH solution is: (a) 1.0×10^{-2} L, (b) 8.75×10^{-2} L, (c) 8.75×10^{-3} L, (d) 1.0×10^{-3} L.
8. Which of the followings is not an oxidizing agent?
   (a) Potassium permanganate, (b) potassium dichromate, (c) oxygen gas, (d) CH_4
9. The mole fraction of nitrogen in the air is 0.7808. The partial pressure of nitrogen in air at the atmospheric pressure of 760 torr is (a) 400 torr, (b) 593 torr, (c) 650 torr, (d) 1 atm.
10. One can qualitatively predict the effects of changes in concentration on a system at equilibrium by using (a) Boyle's Law, (b)Le Chatelier's principle, (c)Charle's Law, (d) Nernst equation.

11. A is a stronger acid than B, which of the following is correct?
    (a) pKa of A is greater than B, (b) Ka of A is greater than B, (c) Ka of A and B are of the same magnitude, (d) Ka is irrelevant to the acid strength

12. Which of the followings is a polyprotic acid? (a) hydrochloric acid, (b) acetic acid, (c) nitric acid, (d) phosphoric acid.
13. Considering the reaction of acetic acid in water

$CH_3CO_2H\,(aq) + H_2O(l) = CH_3CO_2^- + H_3O^+(aq)$

Where $Ka = 1.8 \times 10^{-5}$

Which is the stronger base? (a) CH_3CO_2H, (b) H_2O, (c) $CH_3CO_2^-$, (d) H_3O^+

14. The pH value of 1.0×10^{-2} M sulfuric acid is (a) 2, (b) less than 2, (c) greater than 2, (d) 10
15. A buffered solution contains 0.25 M NH_3 ($Kb = 1.8 \times 10^{-5}$) and 0.40 M NH_4Cl. The pH of this buffer solution is (a) 3.0, (b) 4.5, (c) 9.05, (d) 7.05

16. Proton has the charge of (a) 1-, (b) 1+, (c) none, (d) 2+.
17. (A)$FeCr_2O_4(s)$ + (B)$K_2CO_3(s)$ + (C)$O_2(g)$ → (D)$K_2CrO_4(s)$ + (E)$Fe_2O_3(s)$ + (F)$CO_2(g)$. When the equation is balanced, (A) + (E) = (a) 6, (b) 12, (c) 15, (d) 16.
18. Typical blood serum is about 0.14 M NaCl. What volume of blood contains 1.0 mg of NaCl? (a) 0.8 mL, (b) 1.0 mL, (c) 1.2 mL, (d) 1.4 mL
19. Assign oxidation state of N in NO_3^-, (a) 3, (b) 4, (c) 5, (d) 6.
20. When solving equilibrium problems of a reaction $As_4O_6(s) + 6C(s) = As_4(g) + 6CO(g)$, which changes of conditions will have no effect? (a) addition of CO, (b) addition or removal of C or As_4O_6, (c) removal of As_4, (d) (a) to (c) are all feasible.

21. The pH of a solution contains the same concentration HCN ($Ka = 6.2 \times 10^{-10}$), HNO_2 ($Ka = 4.0 \times 10^{-4}$) and $HC_2H_3O_2$ ($Ka = 1.8 \times 10^{-5}$) aqueous solution. Which will be the main producer of H^+? (a) HCN, (b) HNO_2, (c) $HC_2H_3O_2$, (d) H_2O.
22. 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.
23. The unit of entropy change is (a) $J.mol^{-1}$, (b) $J.K^{-1}$, (c) $J.K^{-1}.mol^{-1}$, (d) $J.l^{-1}.mol^{-1}$
24. For the enthalpy change ΔH and the entropy change ΔS 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) $\Delta S < 0$, $\Delta H > 0$
25. When substances undergo a chemical reaction, the reaction proceeds to equilibrium, which corresponds to the measurement of: (a) entropy change $\Delta S = 0$, (b) standard free energy change $\Delta G^0 = 0$, (c) standard enthalpy change $\Delta H^0 = 0$, (d) $\Delta G = G_{products} - G_{reactants} = 0$

26. The alkaline dry cell lasts longer than the acidic cell mainly because the zinc anode

corrodes less rapidly under basic conditions than under acidic conditions. Here the verb "corrodes" means (a) energy loses, (b) heat transfer, (c) cathode reaction, (d) anode reaction.

27. The largest radius of the following ions is (a) Be^{2+}, (b) Mg^{2-}, (c) Ca^{2+}, (d) Sr^{2+}.
28. For the Lewis structure of CF_4 (indicating shared electron pairs and lone pairs) calculate number of electrons remaining: (a) 12, (b) 24, (c) 4, (d) 8.
29. Diamond is the hardest naturally occurring substance because the structure is stabilized by (a) covalent bonds, (b) metallic bonds, (c) ionic bonds, (d) van der Waal force.
30. For the different phases of Mg, which state will have a stronger bonding? (a) 1 mm Hg, (b) 10 mm Hg, (c) 400 mm Hg, (d) 760 mm Hg.

31. Which function cannot be derived from the first law of thermodynamics? (a) enthalpy; (b) heat; (c) internal energy; (d)entropy
32. Which law of thermodynamics is the center of thermodynamics? (a) 0^{th} law; (b) 1^{st} law; (c) 2^{nd} law; (d) 3^{rd} law.
33. Which process is closest to a thermodynamically reversible process? (a) explosion of a bomb; (b) forest fire; (c) melting of ice cream at room temperature; (d) freezing of water at 0°C.
34. Which property is not a thermodynamic property? (a) heat capacity; (b) heat conductivity; (c) activity; (d) chemical potential.
35. Which system has lowest mechanical efficiency? (a) gasoline engine; (b) steam engine; (c) human body; (d) universe.

36. Enthalpy is equivalent to heat when (a) pressure is constant; (b) volume is constant; (c) temperature is constant; (d) entropy is constant.
37. According to the 2^{nd} law of thermodynamics, the entropy of the universe has to (a) be constant; (b) continue to increase; (c) continue to decrease; (d) decrease to zero then increase.
38. According to Maxwell's equations, the infinitesimal variation of pressure with temperature at constant volume is equivalent to (a) the infinitesimal variation of entropy with volume at constant temperature; (b) the infinitesimal variation of entropy with pressure at constant temperature; (c) the infinitesimal variation of volume with entropy at constant pressure; (d) the infinitesimal variation of pressure with entropy at constant volume.
39. The infinitesimal variation of Gibbs free energy with temperature at constant pressure defines (a) volume; (b) entropy; (c) enthalpy; (d) internal energy.
40. Which property is not necessarily zero at 0°K, even for a system in a state of complete internal equilibrium? (a) entropy; (b) heat capacity; (c) thermal expansion coefficient; (d)

isothermal compressibility.

41. Which of the following statements about the constant-pressure heat capacity (c_p) is correct? (a) c_p of one mole gas equals 5R/2; (b) c_p is proportional to the change of entropy to temperature at constant pressure; (c) the internal energy of a material is proportional to its c_p; (d) the Gibbs free energy of a material is proportional to its c_p.
42. The heat capacity (c_p) of iron is 25 J/mol-K at 1 atm. What is the enthalpy of 1 mole iron at 498K, 1 atm? (a) $25ln(498/298)$ J; (b) 12450 J; (c) 5 kJ; (d) not enough information for calculation.
43. The third law of thermodynamics states (by Nernst) that in any chemical reaction involving only pure, crystalline substance, the change of entropy is zero at the absolute zero of temperature. Therefore, for a chemical reaction, (a) $\Delta S(298K)=0$; (b) $\Delta H(0^oK)=0$; (c) $\Delta G(0^oK)=0$; (d) $\left(\frac{\partial \Delta G}{\partial T}\right)_P = 0$ as $T \rightarrow 0^oK$.
44. At constant pressure, the Gibbs free energy of a pure substance, G(T), must (a) be zero at 298K; (b) be zero at the phase transition temperature; (c) be minimum at the phase transition temperature; (d) decrease with increasing T.

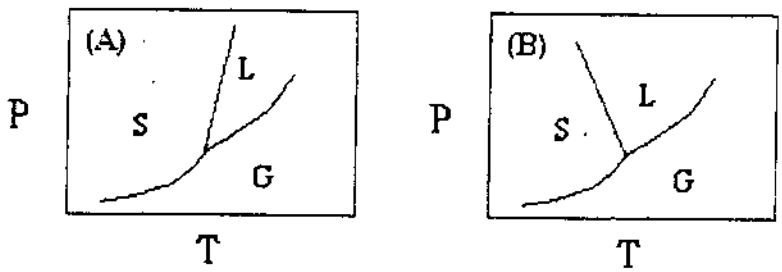
[Prob. 45 and 46] The Clausius-Clapeyron equation states that the variation of vapor pressure with temperature of a pure condensed matter will be: $\frac{d\ln P}{dT} = \frac{\Delta H_{evap.}}{RT^2}$.

45. To find out the vapor pressure at various temperatures, which of the following parameters is NOT necessary? (a) $c_{p(condensed\ phase)}$; (b) $c_{p(vapor\ phase)}$; (c) $\Delta S_{evap.}$ at some T; (d) $\Delta H_{evap.}$ at some T.
46. If the vapor pressure vs. temperature is of the simple form lnP=A/T+B (A, B are constants), then (a) $\Delta G_{evap.}=0$; (b) $\Delta H_{evap.}=0$; (c) $\Delta c_p=c_{p(condensed\ phase)}-c_{p(vapor\ phase)}$=constant; (d) $\Delta c_p=c_{p(condensed\ phase)}-c_{p(vapor\ phase)}=0$.
47. Regarding to the van der Waals equation of state for real gases, which of following statements is NOT correct? (a) It is written as $(P+\frac{a}{V^2})(V-b)=RT$; (b) it predicts correct isothermal P-V curves; (c) if a and b are known, one can calculate the critical point; (d) it predicts that $\Delta H_{(evaporation)}$ falls to zero as the temperature approaches $T_{critical}$.
48. Regarding to the fugacity of gases, which of following statements is correct? (a) Fugacity approaches to 1 atm as pressure approaches to zero; (b) fugacity is proportional to pressure; (c) fugacity is always smaller than pressure; (d) change of fugacity relates with the change of Gibbs free energy.
49. The Gibbs free energy of ideal gas (1 mole) at temperature T is (a) $G^o(T)$; (b) $G^o(T)+RTlnV$; (c) $G^o(T)+RTlnP$; (d) $G^o(T)+(RT/V)lnP$.

50. The thermodynamic activity relates with the change in Gibbs free energy due to the change of (a) temperature; (b) pressure; (c) composition; (d) volume.

51. For an ideal solution between components A and B, which one of the following characteristics is correct:
(a) $\Delta G^M = -RT(X_A \ln X_A + X_B \ln X_B)$
(b) no interaction between A and B
(c) enthalpy can be positive or negative
(d) all of above are correct

(52-53). In the phase diagrams of two pure substances, A and B,

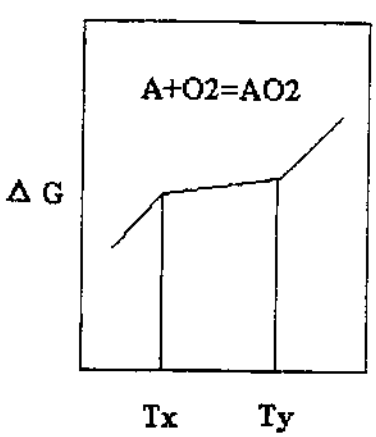


52. which following statement is correct:
(a) the melting point of substance A decreases as the pressure increases,
(b) the melting point of substance B increases as the pressure increases,
(c) the boiling point of substance B increases as the pressure decreases,
(d) none of above are correct

53.From the phase diagram shown above, in the following statement which one is correct:
(a) the volume of substance A increases when it starts to solidify from liquid
(b) the volume of substance B decreases when it starts to boil from liquid
(c) the volume of substance B decreases when it starts to melt from solid
(d) all of above are correct

54. Regarding the thermodynamic function of enthalpy, H, :, which statement is correct:
(a) for an isobaric process, H-U=PV
(b) dH = CpdT, (Cp: Heat capacity at constant pressure)
(c) $dH=q_p$ (q_p:heat change at constant pressure)
(d) all of above are correct.

(55-56). In the figure shown,



(背面仍有題目,請繼續作答)

55. what do the temperatures Tx and Ty represent:
(a) Tx: boiling point of metal A; Ty: boiling point of AO_2
(b) Tx: boiling point of metal A; Ty: melting point of AO_2
(c) Tx: melting point of metal A; Ty: melting point of AO_2
(d) Tx: melting point of metal AO_2; Ty: melting point of A

56. Using the same figure, under what equilibrium condition, there is lowest pO_2
(a) A is solid and AO_2 is solid
(b) A is liquid and AO_2 is solid
(c) A is solid and AO_2 is solid
(d) A is liquid and AO_2 is liquid

(57-60) If the component A and component B in a binary solution A-B obey Henry's law when the molar fraction of solute is less than 0.1. The partial pressure of A in the Herrian solution can be expressed as $P_A = 0.09X_A$ atm and the partial pressure of B in the Herrian solution can be expressed as $P_B = 0.06X_B$ atm at 298K. Assume $P_A^O = 0.06$atm and $P_B^O = 0.05$ atm, whereP_A^O and P_B^O represent the vapor pressures of pure A and B respectively.

57. when the Henry's law is applicable, the activity coefficients of A and B are
(a) 0.66 and 0.833 (b)1.5 and 1.2 (c) 0.833 and 0.66 (d) 1.2 and 1.5

58. When the solution consists of 7% of A and 93% of B, the partial pressures of A and B are:
(a) 0.042atm and 0.0837atm (b) 0.0063 atm and 0.0465 atm (c) 0.042atm and 0.0465 atm (d) 0.0063 atm and 0.0837atm

59. When the solution consists 94% of A and 6% of B, the partial pressure of A and B:
(a) 0.0846atm and 0.0030atm (b) 0.0846atm and 0.0036atm (c) 0.0564atm and 0.0036atm (d) 0.0564atm and 0.0030atm

60. When $X_A = X_B = 0.5$ which of the following can be the possible total vapor pressure ($P_A + P_B$): (a) 0.025atm, (b) 0.070atm, (c) 0.055atm, (d) 0.060atm,

61. The bond angle between carbon atoms in cyclohexane is
(a) 109.5° (b) 120° (c) 60° (d) 90°

62. The alkyl group known as the sec-butyl group is

(a) $CH_3—CH_2—CH_2—CH_2—$

(b) $CH_3—CH_2—\underset{|}{CH}—CH_3$

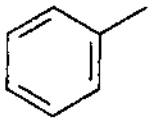
(c) $CH_3—\underset{|}{CH}—CH_2—$ (CH_3 below CH)

(d) $CH_3—\overset{|}{\underset{|}{C}}—CH_3$ (CH_3 below C)

63. 1-Butyne will react with which of the following reagents?
(a) $HgSO_4$ and H_2SO_4(aq) (b) $NaNH_2$

(c) $Cu(NH_3)_2Cl$ (d) HBr

64. An aryl group is

(a) CH_3— (b)  (c) $CH_3-C(=O)-$

(d) $CH_2=C(H)-$

65. The structure of chloroform is

(a) CH_3Cl (b) CH_2Cl_2 (c) $CHCl_3$ (d) CCl_4

66. Which alkyl halide reacts most rapidly by nucleophilic substitution?

(a) CH_3CH_2Cl (b) CH_3CH_2F (c) CH_3CH_2Br (d) CH_3CH_2I

67. The farthest downfield shift will be exhibited by the protons or protons in which compound?

(a) R-CH_3 (b) R-CH_2-Cl (c) R-CHO (d) R-COOH

68. Which infrared region is the characteristic OH or NH absorption?

(a) 3700~3100 cm^{-1} (b) 2400~2000 cm^{-1} (c) 1870~1630 cm^{-1}

(d) 1250~1150 cm^{-1}

69. Which of the following is not a true statement about S_N1 reactions?

(a) The formation of a carbocation is the rate-determining step?

(b) An increase in the concentration of either of the reactants will increase the rate of the reaction?

(c) The designation of S_N1 means substitution, nucleophilic, unimolecular.

(d) An elimination reaction leading to an alkene is a competing reaction.

70. The compound that reacts most readily with metallic sodium is

(a) CH_3CH_2OH (b) $CH_3-CH(CH_3)-OH$ (c) $CH_3-C(CH_3)(CH_3)-OH$

(d) none of them

71. Which product is formed by the oxidation of propionaldehyde

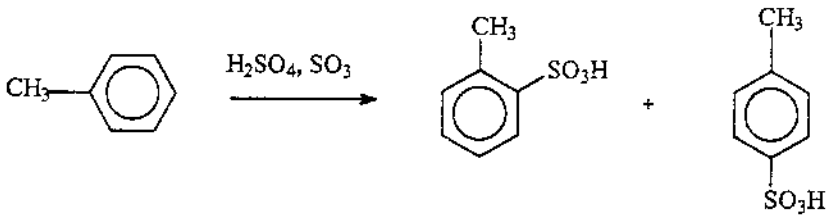
(a) acetic acid (b) formic acid and acetic acid (c) propionic acid

(d) n-propyl alcohol

(背面仍有題目,請繼續作答)

72. Which of the following compounds does not contain a carbonyl group?
(a) Primary alcohol
(b) Primary amide
(c) acid chloride
(d) ethyl ester

73.



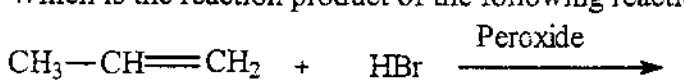
The reaction above belongs to
(a) Elimination reaction
(b) Nucleophilic substitution reaction
(c) Electrophilic addition reaction
(d) Electrophilic substitution reaction

74. The monomer used to make polystyrene is
(a) CH_2=CH_2
(b) CH_2=CHCl
(c) CH_2=$CHCH_3$
(d) CH_2=CHC_6H_5

75. What kind of element containing in a polymer structure can increase its flame resistance?
(a) C (b) O (c) Cl (d) H

76. Which compound reacting with a carboxylic acid will give an ester?
(a) Amine (b) Alcohol (c) ketone (d) aldehyde

77. Which is the reaction product of the following reaction ?



(a) $CH_3CH_2CH_2Br$ (b) $CH_3CHBrCH_2Br$
(c) $CH_3CHBrCH_3$ (d) $CH_3CH_2CH_3$

78. What is the characteristic proton chemical shift range of aromatic hydrogen in proton NMR ?
(a) 1~2 ppm (b) 2~3.5 ppm (c) 4~6 ppm (d) 6~8.5 ppm

79. Which instrument can be used to analyze polymer molecular weight?
(a) GPC (Gel Permeation Chromatography)
(b) ESCA (Electron Spectroscopy for Chemical Analysis)

(c) IR spectroscopy

(d) Raman spectroscopy

80. What is the reaction product of propane with bromine in the dark at room temperature?

(a) $CH_3CH_2CH_2Br$ (b) $CH_3CH_2B_rCH_2Br$

(c) $CH_3CH_2B_rCH_3$ (d) No reaction

81. The Grignard reagent, CH_3CH_2MgBr, can be used in the preparation of

(a) ethane (b) propionic acid (c) 3-ethyl-3-pentanol (d) all of these

82. Which is the strongest acid?

(a) CH_3COOH (b) $ClCH_2COOH$ (c) $Cl_2CHCOOH$ (d) Cl_3CCOOH

83. Which compound has the highest boiling point?

(a) CH_3CH_3 (b) CH_3CH_3OH (c) CH_3OCH_3 (d) CH_3COOH

84. Peptide bonding results in the formation of an

(a) ester (b) aldehyde (c) ether (d) amide

85. The S_N2 reaction is known to occur with

(a) racemization (b) partial inversion (c) almost complete inversion

(d) retention of configuration

86. Which polymer has the highest glass transition (Tg)?

(a) natural rubber (b) poly(ethylene) (c) poly(propylene) (d) polystyrene

87. $NCCH_2CH_2CN \longrightarrow HOOCCH_2CH_2COOH$

Which of the following terms describes a useful method of carrying out the reaction above?

(a) Reduction (b) Acylation (c) Hydrolysis (d) Alkylation

88. Which reaction does not yield an ester as one of the products?

(a) A carboxylic acid is heated with an alcohol in the presence of a mineral acid.

(b) A Grignard reagent is added to a carboxylic acid

(c) An acyl halide is treated with an alcohol

(d) An acid anhydride is treated with an alcohol

89.

The reaction above is an example of which of the following?

(a) Elimination (b) Nucleophilic substitution (c) Electrophilic addition

(d) Aldol condensation?

90. Which of the following combinations describes the effect of a nitro group ($-NO_2$) as a substituent in electrophilic aromatic substitution?

(a) Strongly activating, ortho-para directing

(b) Weakly activating, meta directing

(c) Weakly activating, ortho-para directing

(d) Strongly deactivating, meta directing