I. 選擇題 (每題 2%共 72%)

No. Questions Answer Note

1. According to the law of definite proportions,
   A) if the same two elements form two different compounds, they do so in the same ratio.
   B) it is not possible for the same two elements to form more than one compound.
   C) the ratio of the masses of the elements in a compound is always the same.
   D) the total mass after a chemical change is the same as before the change.

2. Which among the following represent a set of isotopes? Atomic nuclei containing
   I. 20 protons and 20 neutrons.
   II. 21 protons and 19 neutrons.
   III. 22 neutrons and 18 protons.
   IV. 20 protons and 22 neutrons.
   V. 21 protons and 20 neutrons.
   A) I, II, III
   B) III, IV
   C) I, V
   D) I, IV and II, V
   E) No isotopes are indicated.

3. A hydrate of copper(II) sulfate is 25.5% copper by mass. How many water molecules are there for each unit of copper(II) sulfate?
   A) 1
   B) 2
   C) 3
   D) 4
   E) 5

4. A 15-g sample of lithium is reacted with 15 g of fluorine to form lithium fluoride:
   $2Li + F_2 \rightarrow 2LiF$. After the reaction is complete, what will be present?
   A) 2.16 mol lithium fluoride only

   B) 0.789 mol lithium fluoride only
   C) 2.16 mol lithium fluoride and 0.395 mol fluorine
   D) 0.789 mol lithium fluoride and 1.37 mol lithium
   E) none of these

5. Reacting 47.4 mL of 0.320 *M* $AgNO_3$ with 48.0 mL of 0.300 *M* K_2CrO_4 results in what mass of solid formed?
   A) 4.78 g
   B) 2.52 g
   C) 3.40 g
   D) 3.22 g
   E) 1.46 g

6. Balance the reaction below in acidic solution.
   $IO_3^- + I^- \rightarrow I_2$
   What volume of 0.352 *M* HCl is needed to produce 2.48×10^{-3} mol of iodine, I_2, with an excess of KIO_3 and KI?
   A) 2.48 mL
   B) 4.96 mL
   C) 7.05 mL
   D) 14.1 mL
   E) none of these

7. A balloon contains 10.0 g of neon gas. With the temperature kept constant, 10.0 g of argon gas is added. What happens?
   A) The balloon doubles in volume.
   B) The volume of the balloon expands by more than 2 times.
   C) The volume of the balloon expands by less than 2 times.
   D) The balloon stays the same size, but the pressure increases.
   E) none of these

8. A cylinder is fitted with a movable piston. The pressure inside the cylinder is P_i and the volume is V_i. What is the new pressure in the system when the piston decreases the volume of the cylinder by half?
   A) $(1/4)P_i$
   B) $(1/2)P_i$

C) $2P_t$

D) $2V_tP_t$

E) P_t^2

9. The value of the equilibrium constant K depends on:

I. the initial concentrations of the reactants.

II. the initial concentrations of the products.

III. the final concentrations of the reactants.

IV. the final concentrations of the products.

A) I and II only

B) II and III only

C) III and IV only

D) three of these

E) none of these

10. For the reaction $2NCl_3(g) \rightleftharpoons N_2(g) + 3Cl_2(g)$, the equilibrium pressures are

$P(NCl_3) = 0.160$ atm

$P(N_2) = 2.31$ atm

$P(Cl_2) = 0.0565$ atm

Determine K_p for this reaction.

A) 0.816

B) 0.0163

C) 1.22

D) 7.75

E) 61.4

11. Which of the following is a conjugate acid-base pair?

A) HCl/OCl_3^-

B) H_3PO_4/PO_4^{3-}

C) NH_4^+/NH_3

D) H_3O^+/OH^-

E) $Ca^{2+}/Ca(OH)_2$

12. The strong acid HA is added to water. Which of the following is the strongest base in the system?

A) HA

B) H_2O

C) H_3O^+

D) A^-

E) H_2A^-

13. Buffers in the human body

A) help to maintain a constant blood pH.

B) help to keep the body temperature constant.

C) help change the blood plasma pH when foods are eaten.

D) precipitate proteins so enzymes are inactive.

E) none of these

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

$H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \quad pK_a = 6.4$

$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+ \quad pK_a = 7.2$

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

A) $[H_2CO_3] > [HCO_3^-]$ and $[H_2PO_4^-] > [HPO_4^{2-}]$

B) $[H_2CO_3] = [HCO_3^-]$ and $[H_2PO_4^-] > [HPO_4^{2-}]$

C) $[H_2CO_3] = [HCO_3^-]$ and $[HPO_4^{2-}] > [H_2PO_4^-]$

D) $[HCO_3^-] > [H_2CO_3]$ and $[HPO_4^{2-}] > [H_2PO_4^-]$

E) $[H_2CO_3] > [HCO_3^-]$ and $[HPO_4^{2-}] > [H_2PO_4^-]$

15. The ΔH value for the reaction $(1/2)O_2(g) + Cu(s) \rightarrow CuO(s)$ is –156 kJ. How much heat is released when 31.9 g of Cu is reacted with oxygen?

A) 4.98×10^3 kJ

B) 156 kJ

C) 78.4 kJ

D) 62.6 kJ

E) 311 kJ

16. Given the equation $S(s) + O_2(g) \rightarrow SO_2(g)$, $\Delta H = -296$ kJ, which of the following statements is(are) true?

I. The reaction is exothermic.

II. When 0.500 mol of sulfur is reacted, 148 kJ of energy is released.

III. When 32.0 g of sulfur is burned, 2.96×10^5 J of energy is released.

A) All are true.
B) None is true.
C) I and II are true.
D) I and III are true.
E) Only II is true.

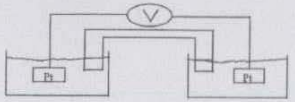
17. One mole of an ideal gas is compressed isothermally at 607.4 K from 5.60 atm to 8.90 atm. If the process is carried out in two irreversible steps (intermediate step at $P = 7.00$ atm), calculate ΔS.

A) 2.34 J/K
B) -2.34 J/K
C) -3.85 J/K
D) 3.85 J/K
E) 0 J/K

18. In an isothermal process, the pressure on 1 mol of an ideal monatomic gas suddenly changes from 4.00 atm to 100.0 atm at 25°C. Calculate w.

A) -59.5 kJ
B) 59.5 kJ
C) 23.5 kJ
D) -23.5 kJ
E) 0

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



0.10 M MnO_4^-
0.20 M Mn^{2+}
0.010 M H^+

0.40 M Cr^{3+}
0.30 M $Cr_2O_7^{2-}$
0.010 M H^+

The standard reduction potentials are as follows:

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ $\quad E° = 1.51$ V

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2\ Cr^{3+} + 7H_2O$ $\quad E° = 1.33$ V

What is the oxidation state of Cr in $Cr_2O_7^{2-}$?

A) +7
B) +6
C) +12
D) −1
E) −2

20. When the equation for the following reaction in basic solution is balanced, what is the sum of the coefficients?

$$MnO_4^-(aq) + CN^-(aq) \rightarrow MnO_2(s) + CNO^-(aq)$$

A) 13
B) 8
C) 10
D) 20
E) 11

21. For an electron in a one-dimensional box, what is the minimum energy to excite the electron from the ground state?

A) $\dfrac{h^2}{8\ mL^2}$

B) $\dfrac{2h^2}{8\ mL^2}$

C) $\dfrac{3h^2}{8\ mL^2}$

D) $\frac{4h^2}{8\ mL^2}$

E) $\frac{5h^2}{8\ mL^2}$

22. How many electrons can be contained in all of the orbitals with $n = 4$?

A) 2
B) 8
C) 10
D) 18
E) 32

23. The electron pair in a C-F bond could be considered

A) closer to C because carbon has a larger radius and thus exerts greater control over the shared electron pair.
B) closer to F because fluorine has a higher electronegativity than carbon.
C) closer to C because carbon has a lower electronegativity than fluorine.
D) an inadequate model because the bond is ionic.
E) centrally located directly between the C and F.

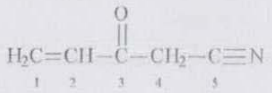
24. What of the following shows the bonds in order of decreasing polarity?

A) N-Cl, P-Cl, As-Cl
B) P-Cl, N-Cl, As-Cl
C) As-Cl, N-Cl, P-Cl
D) P-Cl, As-Cl, N-Cl
E) As-Cl, P-Cl, N-Cl

25. Atoms that are sp^3 hybridized form ____ pi bond(s).

A) 0
B) 1
C) 2
D) 3
E) 4

26. Consider the following molecule. (Lone pairs are not drawn in.)



Specify the hybridization of each carbon atom (in numeric order: C-1 C-2 C-3 C-4 C-5).

A) sp^3 sp^2 sp^2 sp^3 sp
B) sp^2 sp^2 sp^2 sp^3 sp^3
C) sp^2 sp^2 sp^3 sp^3 sp
D) sp^2 ssp^2 sp^3 sp^3 sp^3
E) sp sp sp sp^2 sp

27. The oxidation of Cr^{3+} to CrO_4^{2-} can be accomplished using Ce^{4+} in a buffered solution. The following data were obtained:

Relative Initial Rate	$[Ce^{4+}]_0$	$[Ce^{3+}]_0$	$[Cr^{3+}]_0$
1	2.0×10^{-3}	1.0×10^{-2}	3.0×10^{-2}
2	4.0×10^{-3}	2.0×10^{-2}	3.0×10^{-2}
4	4.0×10^{-3}	1.0×10^{-2}	3.0×10^{-2}
16	8.0×10^{-3}	2.0×10^{-2}	6.0×10^{-2}

Determine the order in the rate law of the species Ce^{3+}.

A) 1
B) 2
C) 3
D) −1
E) −2

28. Tabulated below are initial rate data for the reaction

$$2Fe(CN)_6^{3-} + 2I^- \rightarrow 2Fe(CN)_6^{4-} + I_2$$

Run	$[Fe(CN)_6^{3-}]_0$ (M)	$[I^-]_0$ (M)	$[Fe(CN)_6^{4-}]_0$ (M)	$[I_2]_0$ (M)	Initial Rate (M/s)
1	0.01	0.01	0.01	0.01	1×10^{-5}
2	0.01	0.02	0.01	0.01	2×10^{-5}
3	0.02	0.02	0.01	0.01	8×10^{-5}
4	0.02	0.02	0.02	0.01	8×10^{-5}
5	0.02	0.02	0.02	0.02	8×10^{-5}

What is the experimental rate law?

A) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}]^2[I^-]^2[Fe(CN)_6^{4-}]^2[I_2]$

B) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}]^2[I^-][Fe(CN)_6^{4-}][I_2]$

C) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}]^2[I^-]$

D) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}][I^-]^2$

E) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}][I^-]\,[Fe(CN)_6^{4-}]$

29. Which intermolecular force is the strongest?

A) dipole-dipole interactions
B) London dispersion forces
C) hydrogen bonding
D) ionic bonding
E) polar covalent bonds

30. Chromium metal crystallizes as a body-centered cubic lattice. If the atomic radius of Cr is 1.25 angstroms, what is the density of Cr metal in grams per cubic centimeter?

A) 5.52 g/cm^3
B) 7.18 g/cm^3
C) 7.81 g/cm^3
D) 2.76 g/cm^3
E) 3.59 g/cm^3

31. In a 0.1 molar solution of NaCl in water, which of the following will be closest to 0.1?

A) the mole fraction of NaCl
B) the mass fraction of NaCl
C) the mass percent of NaCl
D) the molality of NaCl
E) All of these are about 0.1.

32. Thyroxine, an important hormone that controls the rate of metabolism in the body, can be isolated from the thyroid gland. If 0.455 g of thyroxine is dissolved in 10.0 g of benzene, the freezing point of the solution is 5.144°C. Pure benzene freezes at 5.444°C and has a value for the molal freezing-point-depression constant of K_f of 5.12°C/m. What is the molar mass of thyroxine?

A) 777,000 g/mol
B) 777 g/mol
C) 2330 g/mol
D) 285 g/mol
E) 3760 g/mol

33. Choose the element with the smallest radius.

A) Li(s)
B) In(s)
C) K(s)
D) Mg(s)
E) Si(s)

34. Which of the following metals has the highest melting point?

A) Na
B) Mg
C) Al
D) Ca
E) K

35. Which of the following statements is true about coordination complexes?

A) The metal is a Lewis base and the ligands are Lewis acids.

B) Only complexes with coordination number 6 are found in nature.

C) When the ligands approach a transition metal ion in an octahedral field, the d_{xz}, d_{yz}, and d_{xy} atomic orbitals are affected the least by the ligands.

D) None of these is true.

E) All of these are true.

36. Choose the most likely pattern for the crystal field diagram for the complex *trans*-$[Ni(NH_3)_2(CN)_4]^{2-}$, where CN^- produces a much stronger crystal field than does NH_3.

A)

B)

C)

D)

E)

I. 計算與問答題 (共 28%)

1. Consider the following reaction: *Ans:*

$$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s), \quad \Delta H = -1390.81\ kJ$$

a) Is the reaction exothermic or endothermic? (2%)

b) Calculate the heat produced when 10.0 g of $AlCl_3$ forms. (2%)

c) How many grams of Al are required to produce 1.00 kJ of energy? (2%)

2. Liquid A has vapor pressure x. Liquid B has vapor pressure y, and $x > y$. What is the mole fraction of A in the liquid mixture if the vapor above the solution is 30% A? (5%)

3. The questions below refer to the following:

Iron-56, $^{56}_{26}Fe$, has a binding energy per nucleon of 8.79 MeV.

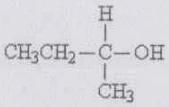
(1 MeV = 1.60×10^{-13} J)

(1) Determine the amount of energy needed to "decompose" 1 mol of iron-56 nuclei. (3%)

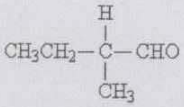
(2) Determine the difference in mass between 1 mol of iron-56 nuclei and the component nucleons of which it is made. (3%)

4. Indicate the following structures are optically active or non optically active as well as indicate the category (*e.g.*, aldehyde, ketone, acid, amine, alcohol, or others). (5%) 答案

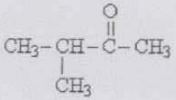
A)



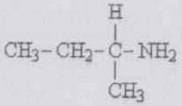
B)



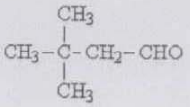
C)



D)



E)



5. A 1.00-mol sample of an ideal monatomic gas is compressed isothermally and irreversibly in one step from 2.50 atm to 6.50 atm at 300.0 K. Calculate w, ΔH, ΔG, and ΔS_{sur} for this process. (6%)

1	C	5	*B*	9	*E*	12	*B*	16	*A*	19	*B*	22	*E*	26	*A*	28	*C*	31	*D*	35	*C*
2	*D*	6	*D*	10	*B*	13	*A*	17	*C*	20	*A*	23	*B*	27	*D*	29	*D*	32	*B*	36	*B*
3	*E*	7	*C*	11	*C*	14	*B*	18	*B*	21	*C*	24	*E*			30	*B*	33	*E*		
4	*D*	8	*C*			15	*C*					25	*A*					34	*C*		

1 *a) exothermic* *Ans:*

b) 52.2 kJ

c) 0.0388 g Al

2. $0.3y/(0.7x + 0.3y)$

3. (1) 4.74×10^{13} J

(2) 5.27×10^{-4} kg

4 *A)* optically active; *alcohol*

B) optically active; aldehyde

C) Non optically active; ketone

D)optically active; amine

E) Non optically active; aldehyde

5 $w = 3.99$ *kJ*,

$\Delta H = 0$,

$\Delta G = 2.38$ *kJ*,

$\Delta S_{surr} = 13.3$ *J/K*