I.　單選題 30 題，每題 3 分，共 90 分

1. A piece of indium with a mass of 16.6 g is submerged in 46.3 cm^3 of water in a graduated cylinder. The water level increases to 48.6 cm^3. The correct value for the density of indium from these data is:
   a) 7.217 g/cm^3　b) 7.2 g/cm^3　c) 0.14 g/cm^3　d) 0.138 g/cm^3
   e) more than 0.1 g/cm^3 away from any of these values.

2. A species with 12 protons and 10 electrons is
   a) Ne^{2+}　b) Ti^{2+}　c) Mg^{2+}　d) Mg　e) Ne^{2-}

3. Rutherford's experiment was important because it showed that:
   a) radioactive elements give off alpha particles.
   b) gold foil can be made to be only a few atoms thick.
   c) a zinc sulfide screen scintillates when struck by a charged particle.
   d) the mass of the atom is uniformly distributed throughout the atom.
   e) an atom is mostly empty space.

4. You heat 3.970 g of a mixture of Fe_3O_4 and FeO to form 4.195 g Fe_2O_3. The mass percent of FeO originally in the mixture was: (atomic mass: Fe, 55.847; O, 15.9994)
   a) 12.1%　b) 28.7%　c) 71.3%　d) 87.9%　e) none of these

5. What is the coefficient for oxygen when the following equation is balanced?
   $NH_3(g) + O_2(g) \rightarrow NO_2(g) + H_2O(g)$
   a) 3　b) 6　c) 7　d) 12　e) 14

6. A 3.00-g sample of an alloy (containing only Pb and Sn) was dissolved in nitric acid (HNO_3). Sulfuric acid was added to this solution, which precipitated 2.93 g of $PbSO_4$. Assuming that all of the lead was precipitated, what is the percentage of Sn in the sample? (molar mass of $PbSO_4$ = 303.3 g/mol. atomic mass: Pb, 207.2; Sn, 118.69)
   a) 33.3% Sn　b) 17.7% Sn　c) 50.0% Sn　d) 66.7% Sn　e) 2.00% Sn

7. Calcium hydride combines with water according to the equation

$CaH_2(s) + 2H_2O(l) \rightarrow 2H_2(g) + Ca(OH)_2(s)$

Beginning with 84.0 g of CaH_2 and 36.0 g of H_2O, what volume of H_2 will be produced at 273 K and a pressure of 1520 torr? (atomic mass: Ca, 40.08. gas constant, 0.08206 L·atm/K·mol)

a) 22.4 L b)44.8 L c) 89.6 L d) 179 L e) none of these

8. Given the heats of the following reactions:

		$\Delta H°$ (kJ)
I.	$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g)$	-1225.6
II.	$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$	-2967.3
III.	$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$	-84.2
IV.	$PCl_3(g) + (1/2)O_2(g) \rightarrow Cl_3PO(g)$	-285.7

Calculate the value of $\Delta H°$ for the reaction below:

$P_4O_{10}(s) + 6PCl_5(g) \rightarrow 10Cl_3PO(g)$

a) -110.5 kJ b) -610.1 kJ c) -2682.2 kJ d) -7555.0 kJ
e) None of these is within 5% of the correct answer.

9. Which of the following concerning second IE's is true?

a) That of Al is higher than that of Mg because Mg wants to lose the second electron, so it is easier to take the second electron away.
b) That of Al is higher than that of Mg because the electrons are taken from the same energy level, but the Al atom has one more proton.
c) That of Al is lower than that of Mg because Mg wants to lose the second electron, thus the energy change is greater.
d) That of Al is lower than that of Mg because the second electron taken from Al is in a p orbital, thus it is easier to take.
e) The second ionization energies are equal for Al and Mg.

10. In the cyanide ion (CN^-), the nitrogen has a formal charge of

a) -2 b) -1 c) 0 d) 2 e) 2

11. Select the molecule among the following that has a dipole moment.

a) CO_2 b) SeO_3 c) XeF_4 d) SF_4 e) $BeCl_2$

12. Which of the following molecules are nonlinear?

NO_2^-, C_2H_2, N_3^-, HCN, CO_2, H_2O_2

a) C_2H_2, HCN b) CO_2, N_3^- c) NO_2^-, H_2O_2 d) N_3^-, N_2^-
e) all are linear

13. Which of the following molecules or ions is not paramagnetic in its ground state?

a) O_2 b) O_2^+ c) B_2 d) NO e) F_2

14. Sodium oxide (Na_2O) crystallizes in a structure in which the O^{2-} ions are in a face-centered cubic lattice and the Na^+ ions are in tetrahedral holes. The number of Na^+ ions in the unit cell is:

a) 2 b) 4 c) 6 d) 8 e) none of these

15–16. The reaction

$$2NOBr \rightarrow 2NO + Br_2$$

exhibits the rate law

$$\text{Rate} = k[NOBr]^2 = -\frac{\Delta[NOBr]}{\Delta t}$$

where $k = 1.0 \times 10^{-5}\ M^{-1} \cdot s^{-1}$ at 25°C. This reaction is run where the initial concentration of NOBr ($[NOBr]_0$) is 1.00×10^{-1} M.

15. What is one half-life for this experiment?

a) 5.0×10^{-1} s b) 6.9×10^{4} s c) 1.0×10^{-5} s
d) 1.0×10^{6} s e) none of these

16. The [NO] after 1.00 hour has passed is

a) 3.5×10^{-4} M b) 9.9×10^{-3} M c) 9.7×10^{-3} M
d) 1.0×10^{-3} M e) none of these

17. At a certain temperature K for the reaction

$$2NO_2 \rightleftharpoons N_2O_4$$

is 7.5 liters/mole. If 2.0 moles of NO_2 are placed in a 2.0-liter container and permitted to react at this temperature, calculate the concentration of N_2O_4 at equilibrium.

a) 0.39 moles/liter b) 0.65 moles/liter c) 0.82 moles/liter
d) 7.5 moles/liter e) none of these

18. For a certain reaction at 25.0°C, the value of K is 1.2×10^{-3}. At 50.0°C the value of K is 3.4×10^{-1}. This means that the reaction is

a) exothermic. b) endothermic. c) never favorable.
d) More information is needed. e) None of these (a-d)

19. A solution of 8.0 M formic acid (HCOOH) is 0.47% ionized. What is the K_a of formic acid?

a) 3.4×10^{-8} b) 1.8×10^{-4} c) 6.9×10^{-6} d) 3.8×10^{-2}
e) need more data

20. The K_{sp} of AgI is 1.5×10^{-16}. Calculate the solubility in mol/L of AgI in a 0.30 M NaI solution.

a) 1.7×10^{-8} b) 0.30 c) 2.6×10^{-17} d) 8.5×10^{17} e) 5.0×10^{-16}

21. Consider the dissociation of hydrogen:

$H_2(g) \rightleftharpoons 2H(g)$

One would expect that this reaction:

a) will be spontaneous at any temperature.
b) will be spontaneous at high temperatures.
c) will be spontaneous at low temperatures.
d) will not be spontaneous at any temperature.
e) will never happen.

22. For the process $CHCl_3(s) \rightarrow CHCl_3(l)$, $\Delta H° = 9.2$ kJ/mol and $\Delta S° = 43.9$ J/mol/K. What is the melting point of chloroform?

a) -63°C b) 210°C c) 5°C d) 63°C e) -5°C

23. In which of the following changes is the work done by the system the largest at 25°C?

a) an isothermal free expansion of an ideal gas from 1 to 10 liters
b) an isothermal expansion of an ideal gas from 1 to 10 liters against an opposing pressure of 1 atm
c) an isothermal expansion of an ideal gas from 1 to 10 liters against an opposing pressure of 5 atm
d) an isothermal reversible expansion of an ideal gas from 1 to 10 liters
e) the work is the same for processes a–d

24. A fuel cell designed to react grain alcohol with oxygen has the following net reaction:

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

The maximum work one mole of alcohol can yield by this process is 1320 kJ. What is the theoretical maximum voltage this cell can achieve?

a) 0.760 V b) 1.14 V c) 2.01 V d) 2.28 V e) 13.7 V

25. How many seconds would it take to deposit 21.40 g of Ag (atomic mass = 107.87) from a solution of $AgNO_3$ using a current of 10.00 amp?

a) 9649 s b) 4825 s c) 3828 s d) 1914 s e) none of these

26. Which of the following is the best explanation as to why lithium is the strongest reducing agent of the alkali metals?

a) The ionization energy of lithium is the highest of the alkali metals.
b) The ionization energy of lithium is the lowest of the alkali metals.
c) The standard reduction potential of lithium is the most positive of the alkali metals.
d) The relatively high charge density of lithium compared to the other alkali metals.
e) none of these

27. What nitrogen-containing compound is used as rocket fuel?

a) nitrous oxide b) ammonia c) nitric oxide
d) hydrazine e) nitrogen dioxide

28. According to crystal field theory, how many unpaired electrons are present in the complex ion $[Fe(H_2O)_6]^{3+}$? The water molecules are weak field ligands.

a) 1 b) 2 c) 3 d) 4 e) 5

29. Calculate the $[H^+]$ in 1.0 M solution of Na_2CO_3 (for H_2CO_3, $K_{a1} = 4.3 \times 10^{-7}$; $K_{a2} = 5.6 \times 10^{-11}$).

a) 7.5×10^{-6} M b) 6.6×10^{-4} M c) 1.3×10^{-2} M
d) 7.5×10^{-13} M e) none of these

30. For the reaction $H_2O(l) \rightarrow H_2O(g)$ at 298 K, 1.0 atm, ΔH is more positive than ΔE by
2.5 kJ/mol. This quantity of energy can be considered to be
    a) the heat flow required to maintain a constant temperature.
    b) the work done in pushing back the atmosphere.
    c) the difference in the H—O bond energy in $H_2O(l)$ compared to $H_2O(g)$.
    d) the value of ΔH itself.
    e) none of these

II. 計算問答題，每題 5 分，共 10 分

1. A chemist is given a white solid that is suspected of being pure cocaine. When 1.22 g of the solid is dissolved in 15.60 g of benzene the freezing point is lowered by 1.32°C. Calculate the molar mass of the solid. The molal freezing point constant (K_f) for benzene is 5.12°C/m.

2. Draw geometric isomers for $[Cr(en)(NH_3)_2I_2]^+$, where en = ethylenediamine, and indicate which is(are) optical active.