說明：1. 答案一律寫在試卷上，否則不予計分。
　　　2. 請依序清楚作答、並標明題號。

一、單選題：（共 60 分。每題 2 分、答錯倒扣 0.5 分、不答不給分亦不扣分）

1. Pressure is defined as force per unit. Which combination of basic units corresponds to this definition?
   (A) kg/m·s (B) kg·m^2/s (C) kg·m/s^2 (D) kg/m·s^2 (E) kg·m^2/s^2

2. Which one of the following molecules is paramagnetic?
   (A) N_2O_2 (B) N_2O_3 (C) N_2O_5 (D) NO (E) N_2O

3. Calculate the formal charge on chlorine in $(ClO_4)^-$. Note 3+ is not one of the choice.
   (A) 1– (B) 1+ (C) 2– (D) 2+ (E) 5+

4. The azimuthal quantum number equals 6, how many distinct magnetic quantum values are possible?
   (A) 6 (B) 12 (C) 13 (D) 3 (E) 7

5. $Na^{2+}O^{2-}$ is less stable than $[Na_2]^{2+}O^{2-}$. This lesser stability is due to
   (A) the very small size of the Na^{2+} ion (B) the large size of the O^{2-} ion relative to Na^{2+}
   (C) the instability of oxide ions in the presence of 2+ ions (D) more energy is required to ionize sodium than would be realized in the attraction between Na^{2+} and O^{2-}
   (E) the statement is false, both materials are stable.

6. Which one of the following molecules possesses a triple bond?
   (A) CO (B) C_2H_4 (C) N_2H_4 (D) SO_2 (E) ClF_3

7. How many valence electrons are required in CF_3OCF_3 to obey the octet rule?
   (A) 40 (B) 32 (C) 48 (D) 60 (E) 56

8. What hybridization change occurs on the P atom when PCl_5 reacts with Cl^- to form the $[PCl_6]^-$?
   (A) sp^4 to sp^5 (B) s^2p^2 to s^2p^3 (C) sp^3d to sp^3d^2 (D) d^5 to d^5s (E) sp^3 to sp^3d^2

9. A term common to Valence Bond and Molecular Orbital Theories is
   (A) resonance forms (B) nonbonding molecular orbitals (C) sigma- and pi-bonds
   (D) linear combination of atomic orbitals (E) hybrid orbitals

10. Which one molecule or ion has a bond order that differs from all other molecules or ions listed below?
   (A) CO (B) CN^- (C) N_2 (D) O_2 (E) $[O_2]^{2+}$

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11. Which characteristic does not describe an ideal gas?
(A) zero volume occupied by an ideal gas   (B) no attractive forces between ideal gas molecules   (C) obeys the following equation $PV = nRT$ (D) PV/RT = a constant   (E) strong repulsions between molecules results in ideal gas behavior

12. Arrange the following molecules, SO_2, Cl_2, and CH_3OH, in the order of increasing intermolecular forces.
(A) SO_2, Cl_2, CH_3OH (B) Cl_2, SO_2, CH_3OH (C) CH_3OH, SO_2, Cl_2 (D) SO_2, CH_3OH, Cl_2 (E) Cl_2, CH_3OH, SO_2

13. Which colligative property measurement is the wisest to use for compounds with molecular weight (M.W.) > 5000 g/mol?
(A) freezing point depression   (B) boiling point elevation   (C) osmotic pressure   (D) vapor pressure changes   (E) titrations

14. Which one of the following processes results in an increase in entropy?
(A) condensation   (B) cooling of a gas   (C) freezing   (D) cooling of a liquid   (E) expansion of a gas

15. To determine whether the data available corresponds to a first order rate expression, a plot of what variables will yield a straight line if A is the unique reactant?
(A) ln [A] vs. 1/t   (B) 1/[A] vs. 1/t   (C) [A] vs. t   (D) $[A]^2$ vs. t   (E) 1/[A] vs. t

16. As water is heated, its pH decreases.   This means that
(A) the water is no longer neutral   (B) the K_w value is decreasing   (C) the water has a lower [OH]⁻ than cooler water   (D) the dissociation of water is an endothermic process   (E) none of above.

17. What is the change in oxidation number of sulfur, when sulfur undergoes the following chemical change? $2S(s) + O_2(g) + 2Cl_2(g) \rightarrow 2SOCl_2(l)$
(A) 0 to 2–   (B) 0 to 3+   (C) 1– to 1+   (D) 0 to 1–   (E) 0 to 4+

18. Which one of the following equalities is correct?
(A) joule = volt/coulomb   (B) joule = coulomb/volt   (C) joule = $(volt)^2$/coulomb   (D) joule = $(volt)^2 \cdot$coulomb   (E) joule = volt·coulomb

19. The ligands in complex ions act as
(A) Lewis acids   (B) Lewis bases   (C) Bronsted-Lowry acids   (D) Arrhenius acids   (E) Arrhenius bases

20. What is the formula for the following compound, Tris(oxalato)ferrate(III) ion?
(A) $[Fe(C_2O_4)_3]^{3-}$ (B) $[Fe(C_2O_4)_3]^{2-}$ (C) $[Fe(C_2O_4)_3]^{1-}$ (D) $[Fe(C_2O_4)_3]^{1+}$ (E) $[Fe(C_2O_4)_3]^{3+}$

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21. Which complex ion should exhibit the smallest crystal field splitting energy?
   (A) $[FeCl_4]^-$ (B) $[Fe(CN)_6]^{3-}$ (C) $[CoCl_4]^{2-}$ (D) $[Co(H_2O)_6]^{2+}$ (E) $[Zn(NH_3)_4]^{2+}$

22. Which one of the following nuclear transformations does not result in the formation of a new element?
   (A) gamma emission (B) beta capture (C) beta emission
   (D) alpha emission (E) double beta emission

23. How does NaH behave in the present of water?
   (A) as a base (B) as a cleaning agent (C) is neutral (D) is amphoteric
   (E) as an oxidizing agent

24. An ozone "hole" results from the presence of high concentrations of one of the following molecules in the atmosphere.
   (A) CO (B) NO (C) CO_2 (D) ClO (E) NO_2

25. Which one of the following groups of elements is found to exhibit ferromagnetic properties?
   (A) Fe, Co (B) Cu, Ti (C) Co, Ti (D) Co, Cu (E) Fe, Cu

26. How many sigma and pi bonds are there in $CH_3COCOCH_3$?
   (A) 11 sigma and 2 pi (B) 12 sigma and 4 pi (C) 14 sigma and 4 pi
   (D) 12 sigma and 6 pi (E) 16 sigma and 4 pi

27. If a five carbon straight chain, how many different ketones are possible?
   (A) 0 (B) 1 (C) 2 (D) 3 (E) 4

28. A mixture of 1-butanol and 2-butanol are allowed to react in the presence of a large excess of an oxidizing agent (potassium dichromate). What two new compounds are produced?
   (A) two aldehydes (B) two ketones (C) an acid and an aldehyde
   (D) an acid and a ketone (E) carbon dioxide and water

29. A polypeptide is a condensation polymer formed from what monomeric units?
   (A) sugars (B) amino acids (C) nucleic acids (D) lipids (E) cholesterol

30. In chemical reactions involving alkanes, halogen atoms can replace hydrogen atoms. These reactions are called
   (A) combustion reactions (B) dehydrogenation reactions (C) substitution reactions
   (D) addition reactions (E) hydrogen reactions.

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二、單選計算題：（共 40 分。每題 4 分、答錯倒扣 1 分、不答不給分亦不扣分）

1. A 10 mg sample of C_xH_y is burned in sufficient oxygen and it produces 30 mg of CO_2 and 16 mg of H_2O. Using this data calculate the value of x and y.
   (A) 1 and 4   (B) 2 and 6   (C) 3 and 8   (D) 2 and 4   (E) 3 and 6

2. The $\Delta H°$ of formation for $H_2O(g)$ and $H_2O(l)$ is -241.82 and -285.83 kJ/mol, respectively. Calculate the ΔH of vaporization, in kJ/mol, for water.
   (A) 263   (B) 44.01   (C) -286 (D) -242 (E) -44

3. An electron has an associated wavelength of 4.0×10^{-6} m. Calculate the velocity of the electron in m/s. $m_e = 9.1 \times 10^{-31}$ kg.
   (A) 365   (B) 1830   (C) 4.0×10^4 (D) 1.8×10^2 (E) 1.8×10^5

4. Calculate the $\Delta G°$ of the following equation:
   $$H_2O_2(l) \rightarrow H_2O(l) + \tfrac{1}{2}O_2(g) \quad \Delta G° = ?$$
   $\Delta G°[H_2O_2] = -120.4$ kJ/mol, $\Delta G°[H_2O] = -237.2$ kJ/mol
   (A) -457.6 (B) 457.6   (C) -116.8 (D) 116.8   (E) -287.2

5. The first-order specific rate constant is found to be 1.37×10^{-3} hr^{-1}. Calculate $t_{1/2}$ in hours.
   (A) 3890   (B) 730   (C) 317   (D) 506   (E) 8.98

6. Calculate the molar solubility of $Ca_3(PO_4)_2$ in water. $K_{sp} = 1.0 \times 10^{-25}$ for $Ca_3(PO_4)_2$.
   (A) 7.8×10^{-6} (B) 1.2×10^{-5} (C) 3.2×10^{-13} (D) 3.9×10^{-6} (E) 2.0×10^{-6}

7. Calculate $E°$ for the following equation:
   $$Fe(s) + 2Fe^{3+}(aq) \rightarrow 3Fe^{2+}(aq) \quad E° = ?$$
   $Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \quad E° = +0.77$ V
   $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s) \quad E° = -0.41$ V
   (A) -0.05 V   (B) $+1.59$ V   (C) $+1.18$ V   (D) $+0.36$ V   (E) -0.36 V

8. A 10% by weight solution of NaCl (Na: 23, Cl: 35.5) in water has a molality of
   (A) 0.127 m   (B) 1.42 m   (C) 1.50 m   (D) 1.85 m
   (E) impossible to determine unless we know the density of the solution.

9. A 1.0-liter solution contains 0.25 M HF and 0.60 NaF (K_a for HF is 7.2×10^{-4}). What is the pH of this solution?
   (A) 1.4   (B) 3.5   (C) 4.6   (D) 2.8   (E) 0.94

10. If K_a equals 10^{-7} for nitric acid, calculate K_b for the nitrate ion.
    (A) 10^{-7} (B) 10^{-14} (C) 10^{-21} (D) 10^{21} (E) 10^7