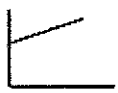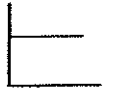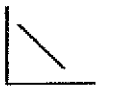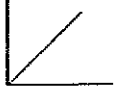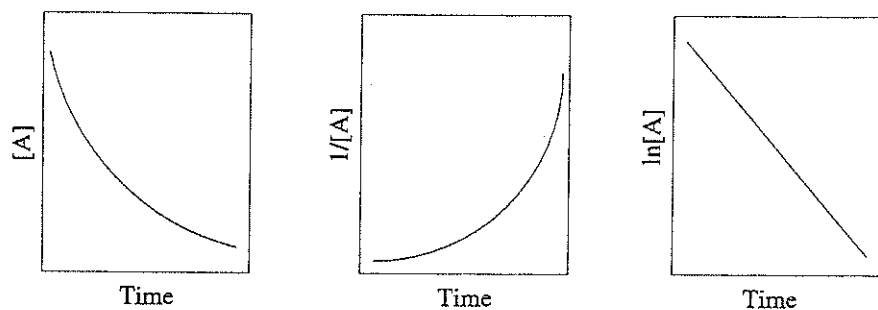單一選擇題，共 25 題，每題 4 分，總分 100 分，答錯不扣分，請在答案卷上作答，考試時間 90 分鐘

1. An element's most stable ion forms an ionic compound with chlorine having the formula XCl_2. If the mass number of the ion is 24 and it has 10 electrons, what is the element and how many neutrons does it have?
    (A) Ne, 14 neutrons
    (B) Ne, 16 neutrons
    (C) O, 16 neutrons
    (D) Mg, 12 neutrons
    (E) Na, 11 neutrons

2. A reaction occurs between sodium carbonate and hydrochloric acid producing sodium chloride, carbon dioxide, and water. The correct set of coefficients, respectively, for the balanced reaction is
    (A) 3, 6, 6, 3, 4.
    (B) 8, 6, 5, 10, 5.
    (C) 5, 10, 10, 5, 5.
    (D) 1, 2, 2, 1, 1.
    (E) none of these

3. An aqueous solution of barium nitrate reacts with an aqueous solution of sodium sulfate. Identify the solid and indicate its coefficient in the balanced equation.
    (A) $NaNO_3$, 1
    (B) $BaSO_4$, 1
    (C) $NaNO_3$, 2
    (D) $BaSO_2$, 2
    (E) $BaNO_3$, 1

4. In the following reaction, which species is the reducing agent?
    $$3Cu + 6H^+ + 2HNO_3 \rightarrow 3Cu^{2+} + 2NO + 4H_2O$$
    (A) H^+
    (B) Cu
    (C) N in NO
    (D) Cu^{2+}
    (E) N in HNO_3

5. How many of the following gases at STP are less dense than air at STP?
    NH_3, He, Kr, and F_2
    (A) 0
    (B) 1
    (C) 2
    (D) 3
    (E) 4

6. The ratio V/n versus the Kelvin temperature of an ideal gas (constant pressure)
   Which graph represents the plot?
   (A)　　　　(B)　　　　(C)　　　　(D)　　　　(E) none of these

7. Consider the equation $A(aq) + 2B(aq) \rightleftharpoons 3C(aq) + 2D(aq)$. 42.0 mL of 0.046 M A is mixed with 24.0 mL 0.105 M B. At equilibrium, the concentration of C is 0.0416 M. Calculate K.
   (A) 2.9×10^{-4}
   (B) 0.074
   (C) 0.033
   (D) 4.8
   (E) 0.0029

8. Consider the equation $2A(g) \rightleftharpoons 2B(g) + C(g)$. At a particular temperature, $K = 1.6 \times 10^{4}$.
   Placing the equilibrium mixture in an ice bath (thus lowering the temperature) will
   (A) cause [A] to increase.
   (B) cause [B] to increase.
   (C) have no effect.
   (D) cannot be determined
   (E) cause [C] to decrease.

9. The acids $HC_2H_3O_2$ and HF are both weak, but HF is a stronger acid than $HC_2H_3O_2$. HCl is a strong acid. Order the following according to base strength.
   (A) $C_2H_3O_2^- > F^- > H_2O > Cl^-$
   (B) $C_2H_3O_2^- > F^- > Cl^- > H_2O$
   (C) $Cl^- > F^- > C_2H_3O_2^- > H_2O$
   (D) $F^- > C_2H_3O_2^- > H_2O > Cl^-$
   (E) $C_2H_3O_2^- > Cl^- > H_2O > F^-$

10. Calculate the pH of a 0.048 M solution of KOH.
    (A) 1.32
    (B) 2.68
    (C) 7.89
    (D) 11.32
    (E) 12.68

11. Methyl orange is an indicator with a K_a of 1×10^{-4}. Its acid form, HIn, is red, while its base form, In$^-$, is yellow. At pH 6.0, the indicator will be
    (A) red.
    (B) orange.
    (C) yellow.
    (D) blue.
    (E) not enough information

12. The two salts AgX and AgY have very similar solubilities in water. The salt AgX is much more soluble in acid than is AgY.　What can be said about the relative strengths of the acids HX and HY?
(A) HY is stronger than HX.
(B) HX is stronger than HY.
(C) Nothing can be said about their relative strengths.
(D) The acids have equal strengths.
(E) Both HX and HY are strong bases.

13. Which statement is true of a process in which 1 mol of a gas is expanded from state A to state B?
(A) When the gas expands from state A to state B, the surroundings are doing work on the system.
(B) The amount of work done in the process must be the same, regardless of the path.
(C) It is not possible to have more than one path for a change of state.
(D) The final volume of the gas will depend on the path taken.
(E) The amount of heat released in the process will depend on the path taken.

14. A 50.0-g sample of a metal is heated to 98.7°C and then placed in a calorimeter containing 395.0 g of water (c = 4.18 J/g°C) at 22.5°C. The final temperature of the water is 24.5°C. Which metal was used?

(A) aluminum (C = 0.89 J/g°C)
(B) iron (C = 0.45 J/g°C)
(C) copper (C = 0.20 J/g°C)
(D) lead (C = 0.14 J/g°C)
(E) none of these

15. Consider the reaction
$2NO_2(g) \rightleftharpoons N_2O_4(g)$　　　$\Delta H° = -56.8$ kJ　　　$\Delta S° = -175$ J/K
In a container (at 298 K), $N_2O_4(g)$ and $NO_2(g)$ are mixed with initial partial pressures of 2.4 atm and 0.42 atm, respectively. Which of the following statements is correct?
(A) The final total pressure must be known to answer this question.
(B) The system is at equilibrium at these initial pressures.
(C) Some $NO_2(g)$ will dimerize to form $N_2O_4(g)$.
(D) Some $N_2O_4(g)$ will decompose into $NO_2(g)$.
(E) None of these statements is correct.

16. For an adiabatic process,
(A) q = 0; w =0
(B) w = 0; ΔE = q
(C) ΔE = 0; q = 0
(D) q = 0; ΔE = -$P_{ext} \Delta V$
(E) none of these

17. For a reaction in a voltaic cell, both $\Delta H°$ and $\Delta S°$ are positive. Which of the following statements is true?
(A) $E°_{cell}$ will increase with an increase in temperature.
(B) $E°_{cell}$ will decrease with an increase in temperature.
(C) $E°_{cell}$ will not change when the temperature increases.
(D) $\Delta G° > 0$ for all temperatures.
(E) $\Delta G° < 0$ for all temperatures.

18. When a battery dies, which of the following is true?
    (A) $\Delta G° = 0$
    (B) $\Delta G = 0$
    (C) $E° = 0$
    (D) Q = 0
    (E) Q = 1

19. An electron in a 10.0-nm one-dimensional box is excited from the ground state into a higher energy state by absorbing a photon with wavelength 1.374×10^{-5} m. Determine the final energy level for this transition.
    (A) $n = 2$
    (B) $n = 3$
    (C) $n = 4$
    (D) $n = 5$
    (E) $n = 6$

20. Typically, rotational changes are produced by radiation in the _____ region of the electromagnetic spectrum.
    (A) UV
    (B) IR
    (C) microwave
    (D) visible
    (E) X-ray

21. Which of the following is diamagnetic?

    (A) N_2
    (B) C_2^+
    (C) H_2^+
    (D) N_2^+
    (E) F_2^+

22. The following data were collected for the decay of HO_2 radicals.

Time	$[HO_2]$	Time	$[HO_2]$
0 s	1.0×10^{11} molec/cm^3	14 s	1.25×10^{10} molec/cm^3
2 s	5.0×10^{10} molec/cm^3	30 s	6.225×10^{9} molec/cm^3
6 s	2.5×10^{10} molec/cm^3		

    Which of the following statements is true?
    (A) The decay of HO_2 occurs by a first-order process.
    (B) The half-life of the reaction is 2 ms.
    (C) A plot of ln $[HO_2]$ versus time is linear with a slope of $-k$.
    (D) The rate of the reaction increases with time.
    (E) A plot of $1/[HO_2]$ versus time gives a straight line.

23. Specify the number of unpaired electrons in $[Mn(H_2O)_4]^{2+}$ (tetrahedral).
    (A) 0
    (B) 2
    (C) 1
    (D) 5
    (E) 4

24. A student was trying to determine the order of a chemical reaction. To accomplish this, the student graphed the concentration - time data using various plotting methodologies. The plots are shown below.

What is the order of the reaction?
(A) zeroth order
(B) first order
(C) second order
(D) It's a combination of 0th and 2nd order.
(E) Need more data to answer the question.

25. Which of the following statements is *false*?
(A) An orbital can accommodate at most two electrons.
(B) The electron density at a point is proportional to ψ^2 at that point.
(C) The spin quantum number of an electron must be either $+1/2$ or $-1/2$.
(D) A 2p orbital is more penetrating than a 2s; that is, it has a higher electron density near the nucleus and inside the charge cloud of a 1s orbital.
(E) In the usual order of filling, the 6s orbital is filled before the 4f orbital.