國立臺灣師範大學 100 學年度碩士班招生考試試題
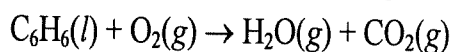
科目：普通化學　　　　　　　　　　　適用系所：科學教育研究所
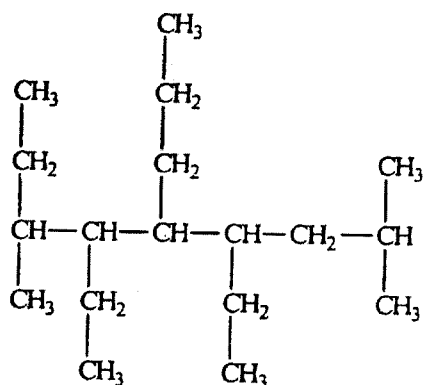
注意：1.本試題共 7 頁，請依序在答案卷上作答，並標明題號，不必抄題。2.答案必須寫在指定作答區內，否則不予計分。

Ⅰ. 問答及計算題，3 題，第一題和第二題各 3 分，第三題為 4 分，共 10 分

1.　Please balance the following equation for the combustion of benzene:

$C_6H_6(l) + O_2(g) \rightarrow H_2O(g) + CO_2(g)$

2.　Please give the correct name for this compound.

3.　For the reaction $3A(g) + 2B(g) \rightarrow 2C(g) + 2D(g)$, the following data were collected at constant temperature. Please provide the correct rate law for this reaction.

Trial	Initial [A] (mol/L)	Initial [B] (mol/L)	Initial Rate (mol/(L·min))
1	0.200	0.100	6.00×10^{-2}
2	0.100	0.100	1.50×10^{-2}
3	0.200	0.200	1.20×10^{-1}
4	0.300	0.200	2.70×10^{-1}

II. 單一選擇題，30 題，每題 3 分，共 90 分

1. Select the answer that expresses the result of this calculation with the correct number of significant figures. $\dfrac{13.602 \times 1.90 \times 3.06}{4.2 \times 1.4097} =$

   [A] 13.3568   [B] 13.357   [C] 13.36   [D] 13.4   [E] 13

2. A student makes several measurements of the density of an unknown mineral sample. She then reports the average value of these measurements. The number of significant figures she uses in her result should be a measure of its

   [A] accuracy   [B] precision   [C] systematic error   [D] determinate error   [E] human error

3. Rutherford bombarded gold foil with alpha (a) particles and found that a small percentage of the particles were deflected. Which of the following was **not** accounted for by the model he proposed for the structure of atoms?

   [A] the small size of the nucleus

   [B] the charge on the nucleus

   [C] the total mass of the atom

   [D] the existence of protons

   [E] the presence of electrons outside the nucleus

4. Terephthalic acid, used in the production of polyester fibers and films, is composed of carbon, hydrogen, and oxygen. When 0.6943 g of terephthalic acid was subjected to combustion analysis it produced 1.471 g CO_2 and 0.226 g H_2O. If its molar mass is between 158 and 167 g/mol, what is its molecular formula?

   [A] $C_4H_6O_7$ [B] $C_6H_8O_5$ [C] $C_7H_{12}O_4$ [D] $C_4H_3O_2$ [E] $C_8H_6O_4$

5. How many milliliters of 1.58 M HCl are needed to react completely with 23.2 g of $NaHCO_3$ (M = 84.02 g/mol)?

   $HCl(aq) + NaHCO_3(s) \rightarrow NaCl(s) + H_2O(l) + CO_2(g)$

   [A] 638 mL   [B] 572 mL   [C] 536 mL   [D] 276 mL   [E] 175 mL

6. In the following reaction, what ions, if any, are spectator ions?

 $Pb(NO_3)_2(aq) + 2NaCl(aq) \rightarrow PbCl_2(s) + 2NaNO_3(aq)$

   [A] $Pb^{2+}(aq)$, $Cl^-(aq)$ [B] $Na^+(aq)$, $NO_3^-(aq)$ [C] $Pb^{2+}(aq)$, $NO_3^-(aq)$ [D] $Na^+(aq)$, $Cl^-(aq)$

   [E] There are no spectator ions in this reaction.

7. Which one of the following is **not** a redox reaction?

[A] $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

[B] $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

[C] $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

[D] $Fe_2O_3(s) + 3H_2SO_4(aq) \rightarrow Fe_2(SO_4)_3(aq) + 3H_2O(l)$

[E] $2KMnO_4(aq) + 10FeSO_4(aq) + 8H_2SO_4(aq) \rightarrow$
$K_2SO_4(aq) + 2MnSO_4(aq) + 5Fe_2(SO_4)_3(aq) + 8H_2O(l)$

8. Which of the lines on the figure below is the best representation of the relationship between the volume of a gas and its Celsius temperature, other factors remaining constant?
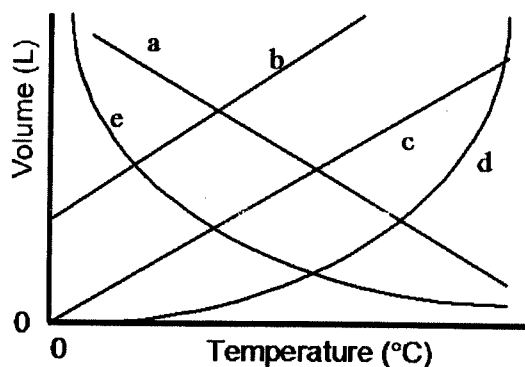
[A] a [B] b [C] c [D] d [E] e

9. A gas consists of 85.7 % carbon and 14.3% hydrogen, by weight. A sample of this gas weighing 0.673 g occupies 729 mL at a pressure of 720.0 mmHg and a temperature of 77°C. Calculate its empirical and molecular formulas.

[A] CH, C_2H_2 [B] CH_2, C_2H_4 [C] CH_2, C_3H_6 [D] CH_3, C_2H_6 [E] CH_4, CH_4

10. In which of the following processes is $\Delta H = \Delta E$?

[A] Two moles of ammonia gas are cooled from 325°C to 300°C at 1.2 atm.

[B] One gram of water is vaporized at 100°C and 1 atm.

[C] Two moles of hydrogen iodide gas react to form hydrogen gas and iodine gas in a 40-L container.

[D] Calcium carbonate is heated to form calcium oxide and carbon dioxide in a container with variable volume.

[E] One mole of solid carbon dioxide sublimes to the gas phase.

11. Which of the following is not a state function?

    [A] internal energy   [B] volume   [C] work   [D] pressure   [E] enthalpy

12. Atomic orbitals developed using quantum mechanics

    [A]   describe regions of space in which one is most likely to find an electron.

    [B]   describe exact paths for electron motion.

    [C]   give a description of the atomic structure which is essentially the same as the Bohr model.

    [D]   allow scientists to calculate an exact volume for the hydrogen atom.

    [E]   are in conflict with the Heisenberg Uncertainty Principle.

13. The effective nuclear charge for an atom is less than the actual nuclear charge due to

    [A]   shielding.   [B]   penetration.   [C]   paramagnetism.

    [D]   electron-pair repulsion.   [E]   relativity.

14. "Electrons added to atomic orbitals of the same energy will remain unpaired with parallel spins until the subshell is more than half-filled" is a statement of

    [A]   the aufbau principle.   [B]   Hund's rule.   [C] the Pauli exclusion principle.

    [D]   the periodic law.   [E]   the singularity rule.

15. Select the correct electron configuration for Cu ($Z = 29$).

    [A] $[Ar]4s^2 3d^9$ [B] $[Ar]4s^1 3d^{10}$ [C] $[Ar]4s^2 4p^6 3d^3$

    [D] $[Ar]4s^2 4d^9$ [E] $[Ar]5s^2 4d^9$

16. In the following Lewis structure for phosphate, phosphorus has a formal charge of ____ and an oxidation number of ____.

    $$\left[\begin{array}{c} :\overset{..}{O}: \\ | \\ :\overset{..}{O}-P=\overset{..}{\underset{..}{O}} \\ | \\ :\overset{..}{\underset{..}{O}}: \end{array} \right]^{3-}$$ [A] 0,-3   [B] 0,5   [C] 5,-3   [D] 5,5   [E] 3,5

17. According to the molecular orbital (MO) treatment of the NO molecule, what are the bond order and the number of unpaired electrons, respectively?

    [A] 2,2   [B] 3,3   [C] 1,1   [D] 1.5,2   [E] 2.5,1

18. Consider the following phase diagram and identify the process occurring as one goes from point C to point D.
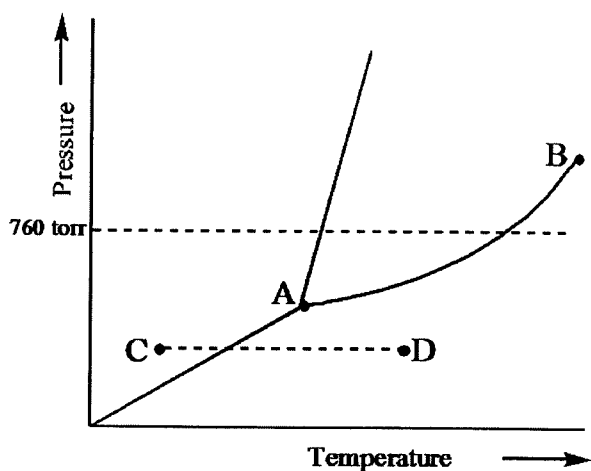
[A] increasing temperature with a phase change from solid to liquid

[B] increasing temperature with a phase change from solid to vapor

[C] increasing temperature with a phase change from liquid to vapor

[D] increasing temperature with no phase change

[E] increasing temperature beyond the critical point

19. The Tyndall effect
    [A] is observed in concentrated solutions.
    [B] is observed only in dilute solutions.
    [C] is observed in colloidal dispersions.
    [D] is caused by Brownian motion.
    [E] is used to determine the osmotic pressure of solutions.

20. Which of the following statements about the effective nuclear charge, Z_{eff}, is correct?
    [A] Z_{eff} increases with the size of the atom.
    [B] Z_{eff} decreases across a period and increases down a group.
    [C] Z_{eff} increases across a period and is relatively constant down a group.
    [D] Z_{eff} increases as the value of the principal quantum number increases.
    [E] Z_{eff} is greater for hydrogen than for any other element.

21. Select the correct name for the following compound.
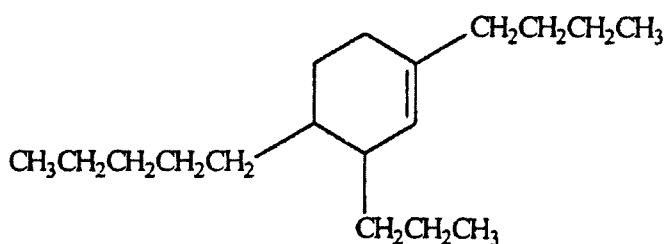
[A] 1-butyl-4-pentyl-3-propylcyclohexene
[B] 1-butyl-4-pentyl-5-propylcyclohexene

[C] 2-butyl-5-pentyl-6-propylcyclohexene

[D] 4-butyl-1-pentyl-2-propylcyclohexene

[E] 1-butyl-4-pentyl-3-propylbenzene

22. An increase in temperature increases the reaction rate because

[A] a greater fraction of the collisions have the correct orientation of molecules.

[B] the activation energy of the reaction will increase.

[C] the activation energy of the reaction will decrease.

[D] temperature acts as a catalyst in chemical reactions.

[E] more collisions will have enough energy to exceed the activation energy.

23. A catalyst accelerates a reaction because

[A] it increases the number of molecules with energy equal to or greater than the activation energy.

[B] it lowers the activation energy for the reaction.

[C] it increases the number of collisions between molecules.

[D] it increases the temperature of the molecules in the reaction.

[E] it supplies energy to reactant molecules.

24. Which of the following has an effect on the magnitude of the equilibrium constant?

[A] removing products as they are formed

[B] adding more of a reactant

[C] adding a catalyst

[D] increasing the pressure, in a gas-phase reaction

[E] change in temperature

25. Consider the equilibrium reaction: $H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$

Which of the following correctly describes the relationship between K_c and K_p for the reaction?

[A] $K_p = K_c$ [B] $K_p = (RT)K_c$ [C] $K_p = (RT)^2 K_c$ [D] $K_p = K_c/RT$ [E] $K_p = K_c/(RT)^2$

26. The solubility of magnesium phosphate is 2.27×10^{-3} g/1.0 L of solution. What is the K_{sp} for $Mg_3(PO_4)_2$?

[A] 6.5×10^{-12} [B] 6.0×10^{-14} [C] 5.2×10^{-24} [D] 4.8×10^{-26} [E] 1.0×10^{-26}

27. A certain process has $\Delta H° > 0$, $\Delta S° < 0$, and $\Delta G° > 0$. The values of $\Delta H°$ and $\Delta S°$ do not depend on the temperature. Which of the following is a correct conclusion about this process?

[A] It is non-spontaneous at all T.

[B] It is spontaneous at high T.

[C] It is spontaneous at low T.

[D] It is spontaneous at all T.

[E] None of these conclusions is correct.

28. Consider the figure below which shows $\Delta G°$ for a chemical process plotted against absolute temperature.
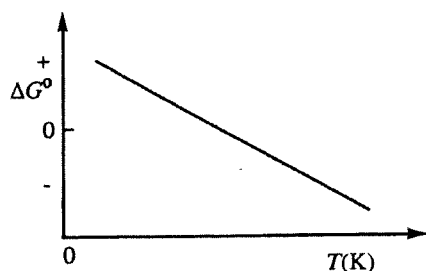
From this plot, it is reasonable to conclude that:

[A] $\Delta H° > 0, \Delta S° > 0$

[B] $\Delta H° > 0, \Delta S° < 0$

[C] $\Delta H° < 0, \Delta S° > 0$

[D] $\Delta H° < 0, \Delta S° < 0$

[E] None of these choices is correct.

29. A voltaic cell prepared using aluminum and nickel has the following cell notation.

$Al(s) \,|\, Al^{3+}(aq) \,\|\, Ni^{2+}(aq) \,|\, Ni(s)$

Which of the following reactions occurs at the anode?

[A] $Al(s) \rightarrow Al^{3+}(aq) + 3e^-$

[B] $Al^{3+}(aq) + 3e \rightarrow Al(s)$

[C] $Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$

[D] $Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$

[E] None of these choices is correct.

30. Balance the following redox equation using the smallest integers possible and select the correct coefficient for the bromide anion, Br^-.

$Br_2(aq) + OH^-(aq) \rightarrow Br^-(aq) + BrO_3^-(aq) + H_2O(l)$

[A] 1   [B] 2   [C] 5   [D] 6   [E] 10