

國立成功大學  
110學年度碩士班招生考試試題

編 號： 90

系 所： 材料科學及工程學系

科 目： 物理與化學

日 期： 0202

節 次： 第 1 節

備 註： 可使用計算機

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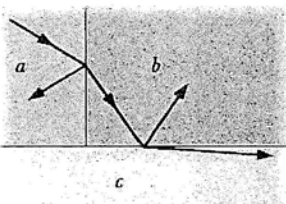
考試日期：0202，節次：1

第 1 頁，共 7 頁

※ 考生請注意：本試題可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。物理與化學共 50 題選擇題，每題答對得 2 分，答錯倒扣 0.5 分；滿分 100 分，倒扣至 0 分為止。

1. Consider the following reaction:  $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$ , The element being oxidized and the oxidizing agent are:  
(a) N and  $\text{NH}_3$       (b) N and  $\text{O}_2$       (c) O and  $\text{O}_2$       (d) O and  $\text{NH}_3$
2. Many cosmologists believe that the entire universe is expanding. Which of the following effects is relevant to such an assumption?  
(a) Compton effect      (b) Doppler effect      (c) Photoelectric effect      (d) Zeeman effect.
3. Place the species in order of the shortest to the longest nitrogen-oxygen bond.  
(a)  $\text{H}_2\text{NOH} < \text{N}_2\text{O} < \text{NO}^+ < \text{NO}^{2-} < \text{NO}^3-$ , (b)  $\text{NO}^+ < \text{NO}^3- < \text{N}_2\text{O} < \text{NO}^{2-} < \text{H}_2\text{NOH}$ , (c)  $\text{NO}^3- < \text{NO}^{2-} < \text{N}_2\text{O} < \text{NO}^+ < \text{H}_2\text{NOH}$ ,  
(d)  $\text{H}_2\text{NOH} < \text{NO}^3- < \text{NO}^{2-} < \text{N}_2\text{O} < \text{NO}^+$ , (e)  $\text{NO}^+ < \text{N}_2\text{O} < \text{NO}^{2-} < \text{NO}^3- < \text{H}_2\text{NOH}$ .
4. High speed electrons have wavelength of order  
(a)  $10^{-15}$  m      (b)  $10^{-14}$  m      (c)  $10^{-16}$  m      (d)  $10^{-17}$  m      (e)  $10^{-12}$  m.
5. Which element has the lowest first ionization energy?  
(a) Ne      (b) Ar      (c) Kr      (d) Xe
6. A uniform solid bowling ball (mass  $M$ , radius  $R$ ) is launched in pure translation (without rotation) along the bowling alley floor with an initial speed  $v_0$ . During an initial distance  $D$ , it partially slides while gaining rotational speed, after which it rolls without slipping. The constant force of friction is  $f$ . In terms of the given symbols, find the linear speed  $v$  of the ball when it begins to roll without slipping.  
(a)  $5v_0/7$       (b)  $3v_0/7$       (c)  $3v_0/5$       (d)  $5v_0/3$
7. For the ionization energy,  
(a) it is the energy needed to remove an electron from a neutral atom in the solid phase.  
(b) it is the same with electron affinity.  
(c) the first ionization energy is always higher than the second ionization energy.  
(d) the first ionization energy principally rises from the left to right across a periodic table with few exceptions only.

8. If the outer electronic configuration of  $Dy^{3+}$  ion is  $5s^2 5p^6 4f^9$ , what is the total spin quantum number for the ground state of  $Dy^{3+}$ ?  
 (a)  $3/2$  (b)  $5/2$  (c)  $7/2$  (d)  $9/2$
9. Which one of the following hydrogen bonds is the strongest?  
 (a) O-H-O (b) O-H-N (c) O-H-F (d) F-H-F (e) F-H-N.
10. In considering the magnetic vector potential would be a vector, which of the following description is true?  
 (a) Which is equal to the vector product  $E \times H$  (b) Whose divergence is equal to electric potential  
 (c) Whose curl is equal to the electric field intensity (d) Whose curl is equal to the magnetic flux density.
11. Arrange the following bonds according to increasing polarity.  
 (a)  $H_2 < SH < ClH < OH < FH$ , (b)  $H_2 < SH < OH < ClH < FH$ , (c)  $H_2 < SH < FH < ClH < OH$ ,  
 (d)  $SH < ClH < OH < FH < H_2$ , (e)  $H_2 < OH < ClH < FH$ .
12. Use the wave equation to find the speed of a wave given in terms of the general function  $h(x, t)$ :  
 $y(x, t) = (4.00 \text{ mm}) h[(30 \text{ m}^{-1})x + (6.0 \text{ s}^{-1})t]$ .  
 (a) 5 m/s (b) 7.5 m/s (c) 0.2 m/s (d) 1.5 m/s (e) 24 m/s.
13. Consider the reaction:  $2 \text{NaHCO}_3(s) \rightleftharpoons \text{Na}_2\text{CO}_3(s) + \text{CO}_2(g) + \text{H}_2\text{O}(g)$  with its equilibrium constant  $K_p = 0.25 \text{ atm}^2$  at  $125^\circ\text{C}$ . A container contains 5.0 g of  $\text{NaHCO}_3$ . What is the minimum container volume required for all  $\text{NaHCO}_3$  to decompose?  
 (a) 2.1 L (b) 2.5 L (c) 1.3 L (d) 2.3 L (e) 1.9 L.
14. Max Planck's great discovery was that radiation energy is emitted in packets that he called what?  
 (a) Quanta (b) Photon (c) Wave functions (d) Gamma rays (e) Phonon.
15. Please arrange the following ionic compounds, LiF, KBr, and MgO, in order of decreasing lattice energy.  
 (a)  $\text{MgO} > \text{LiF} > \text{KBr}$ . (b)  $\text{MgO} > \text{KBr} > \text{LiF}$ . (c)  $\text{KBr} > \text{LiF} > \text{MgO}$ . (d)  $\text{LiF} > \text{MgO} > \text{KBr}$ . (e)  $\text{LiF} > \text{KBr} > \text{MgO}$
16. In the consideration of the Maxwell law, the curl of the electric field intensity would be which of the following?  
 (a) Conservative (b) Rotational (c) Divergent (d) Static.
17. Bond angle of  $\text{SO}_2$  is  
 (a) 180, (b) 120, (c) 109.5, (d) 90, (e) 60 degree.

18. If, in a two-slit interference pattern, there are 7 bright fringes within the first side peak of the diffraction envelope and diffraction minima coincide with two-slit interference maxima, then what is the ratio of slit separation to slit width?
- (a) 6                      (b) 9                      (c) 8                      (d) 5                      (e) 7.
19. For the formation of multiple bonds within molecules,
- (a) the number of bonds is related to the degree of polarization.  
(b) the hybridization of orbitals causes the decrease of bond number.  
(c) the molecular shape is strongly influenced because the rotation of a part of molecule relative to the others is prevented.  
(d) it is more likely found with the increase of atom size.
20. What is the number of energy states in the hydrogen atom for a given principle quantum number of  $n$ ?
- (a)  $2n+1$                       (b)  $2n$                       (c)  $2n^2$                       (d)  $2n^2+1$ .
21. Assume the synthesis of  $\text{NH}_3(g)$  from  $\text{N}_2(g)$  and  $\text{H}_2(g)$ , 2 moles of  $\text{N}_2$  and 6 mole  $\text{H}_2$  are mixed in a 2-liter flask. The equilibrium constant for the synthesis reaction at  $500^\circ\text{C}$  is  $6.0 \times 10^{-2} \text{ L}^2/\text{mol}^2$ . What is the equilibrium concentration of  $\text{NH}_3$ ?
- (a) 0.31 M                      (b) 0.62 M                      (c) 0.16 M                      (d) 0.91 M                      (e) 0.42 M.
22. The below figure shows rays of monochromatic light propagating through three materials  $a$ ,  $b$ , and  $c$ . Rank the materials according to the index of refraction (a)  $a > b > c$  (b)  $b < c < a$  (c)  $b > a > c$  (d)  $c > b > a$ .
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23. Which of the following salt will its solubility in water depend on pH?
- (a)  $\text{PbCl}_2$                       (b)  $\text{Ni}(\text{NO}_3)_2$                       (c)  $\text{AgCl}$                       (d)  $\text{AgNO}_3$                       (e)  $\text{Ag}_3\text{PO}_4$ .
24. Which of the following cannot be a quantized quantity?
- (a) Position  
(b) The direction of angular momentum  
(c) The magnitude of angular momentum  
(d) Energy  
(e) None of the above

25. Please identify the processes of (1) and (2) in the following reaction: solute + solvent  $\xrightarrow[\text{(2)}]{\text{(1)}}$  solution.  
 (a) (1): crystallize; (2): dissolve. (b) (1): dissolve; (2): crystallize. (c) (1): dissolve; (2): evaporate.  
 (d) (1): evaporate; (2): dissolve. (e) (1): crystallize; (2): boil.

26. The maximum electric field 10 m from an isotropic point source of light is 2.0 V/m. What is the average intensity of the light there?  
 (a) 5.8 mW/m<sup>2</sup> (b) 5.3 mW/m<sup>2</sup> (c) 3.0 mW/m<sup>2</sup> (d) 2.0 mW/m<sup>2</sup>.

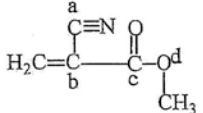
27. Bond order is defined as follows: bond order =  $\frac{1}{2} \times$  (number of bonding electrons – number of antibonding electrons). What is the bond order of He<sub>2</sub><sup>+</sup> ion?  
 (a) 0. (b) 1. (c) 1/2. (d) 3/2. (e) 2.

28. Two objects, O<sub>1</sub> and O<sub>2</sub> have charges 1.0 × 10<sup>-6</sup> C and -2.0 × 10<sup>-6</sup> C respectively, and a third object, O<sub>3</sub> is electrically neutral. The electric flux through the surface that encloses all the three objects is \_\_\_\_\_ Nm<sup>2</sup>/C. (Vacuum permittivity = 8.854 × 10<sup>-12</sup> C<sup>2</sup>N<sup>-1</sup>m<sup>-2</sup>).  
 (a) -1.1 × 10<sup>-7</sup> (b) -1.1 × 10<sup>-5</sup> (c) -1.1 × 10<sup>-3</sup> (d) -1.1 × 10<sup>-1</sup>

29. Titanium metal has a body-centered cubic unit cell. The density of titanium is 4.50 g/cm<sup>3</sup>. What is the edge length (pm) of unit cell of titanium? (for titanium, atomic number is 22, standard atomic weight is 47.867)  
 (a) 200 (b) 252 (c) 328 (d) 380 (e) 156.

30. The specific heat of a substance is:  
 (a) the amount of heat energy to change the state of one gram of the substance  
 (b) the amount of heat energy per unit mass emitted by oxidizing the substance  
 (c) the amount of heat energy per unit mass to raise the substance from its freezing to its boiling point  
 (d) the amount of heat energy per unit mass to raise the temperature of the substance by 1° C.

31. Predict approximate bond angle at each C and O for the following structure.



a/b/c/d=

(a) 109.5, 120, 120, 90, (b) 109.5, 120, 90, 90, (c) 180, 120, 120, 109.5,  
 (d) 180, 120, 180, 120, (e) 180, 120, 120, 90.

32. Ethanol of density  $\rho = 791 \text{ kg/m}^3$  flows smoothly through a horizontal pipe that tapers in crosssectional area from  $A_1 = 1.20 \times 10^{-3} \text{ m}^2$  to  $A_2 = \frac{A_1}{2}$ . The pressure difference between the wide and narrow sections of pipe is  $4120 \text{ Pa}$ . What is the volume flow rate of the ethanol?  
 (a)  $2.24 \times 10^{-3} \text{ m}^3/\text{s}$  (b)  $2.24 \times 10^{-2} \text{ m}^3/\text{s}$  (c)  $2.24 \times 10^{-1} \text{ m}^3/\text{s}$  (d)  $2.24 \times 10^0 \text{ m}^3/\text{s}$ .
33. In UV spectra, which transition shows the appearance of the spectra?  
 (a)  $\pi-\pi^*$  and  $n-\sigma^*$ , (b)  $\pi-\pi^*$  and  $\sigma-\sigma^*$ , (c)  $n-\pi^*$  and  $\sigma-\sigma^*$ , (d)  $\pi-\pi^*$  and  $n-\pi^*$ , (e)  $\pi-\pi^*$  only.
34. A uniform spring of unstressed length  $l$  and force constant  $k$  is cut in two so that one piece is triple as long as the other. If identical masses were hung on one end of each piece, what would be the ratio of the frequencies?  
 (a) 3:1 (b)  $\sqrt{3}:1$  (c) 3:2 (d)  $\sqrt{3}:\sqrt{2}$ .
35. We know that the speeds of gas molecules are proportional to the square root of their kinetic energy. Given the kinetic energy of a gas is  $\frac{3}{2}RT$ , which one of the following gases will have the highest speed at the same temperature?  
 (a)  $\text{CO}_2$  (b)  $\text{O}_2$  (c)  $\text{CH}_3$  (d)  $\text{N}_2$ .
36. A 16-cm-diameter circular loop of wire is placed in a 0.50-T magnetic field. When the plane of the loop is perpendicular to the field lines, what is the magnetic flux through the loop?  
 (a)  $1.0 \times 10^{-1} \text{ Wb}$  (b)  $1.0 \times 10^{-2} \text{ Wb}$  (c)  $1.0 \times 10^{-3} \text{ Wb}$  (d)  $1.0 \times 10^{-4} \text{ Wb}$ .
37. Which of the following has the lowest boiling point?  
 (a) n-Hexane (b) n-Pentane (c) Isopentane (d) Neopentane (e) Neohexane.
38. A water-slide ride in which a glider is shot by a spring along a water-drenched (frictionless) track that takes the glider from a horizontal section down to ground level. As the glider then moves along ground-level track, it is gradually brought to rest by friction. The total mass of the glider and its rider is  $m$  ( $\text{kg}$ ), the initial compression of the spring is  $d$  ( $\text{m}$ ), the spring constant is  $k$  ( $\text{N/m}$ ), the initial height is  $h$  ( $\text{m}$ ), and the coefficient of kinetic friction along the ground-level track is  $\mu$ . Through what distance does the glider slide along the ground-level track until it stops?  
 (a)  $\frac{kd^2}{2\mu mg} - \frac{h}{\mu}$  ( $\text{m}$ ) (b)  $\frac{kd^2}{2\mu mg} + \frac{h}{\mu}$  ( $\text{m}$ ) (c)  $\frac{kd^2}{2\mu mg} + \frac{h}{\mu g}$  ( $\text{m}$ ) (d)  $\frac{kd^2}{2\mu mg} - \frac{h}{\mu g}$  ( $\text{m}$ ).

39. Please convert 0.5 atm to mmHg.  
 (a) 76 mmHg. (b) 760 mmHg. (c) 38 mmHg. (d) 380 mmHg. (e) Cannot convert.
40. A grindstone rotates at constant angular acceleration  $\alpha$  ( $rad/s^2$ ). At time  $t = 0$ , it has an angular velocity of  $\omega_0$  ( $rad/s$ ) and a reference line on it is horizontal, at the angular position  $\theta_0$ . What is the angular position of the reference line after  $t$  (s)?  
 (a)  $\theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$  (b)  $\theta_0 + \omega_0 t + \alpha t^2$  (c)  $\theta_0 + \omega_0 t + 2\alpha t^2$  (d)  $\theta_0 + \omega_0 t + 3\alpha t^2$ .
41. What salt is formed in the following acid/base reaction?  $HClO_3 + Ba(OH)_2 \rightarrow$   
 (a)  $BaCl_2$  (b)  $Ba(ClO_3)_2$  (c)  $ClO_3Ba$  (d)  $BaClO_3$ .
42. A merry-go-round revolves at a constant angular speed of 0.50 rad/s in a counter-clockwise direction when viewed from above. A 40-kg rider walks tangentially (in the same direction the merry-go-round is moving) at a constant speed of 2m/s relative to the merry-go-round, maintaining a constant radius of 2m from the axis. Analyze the situation in the rotating frame to find the magnitude and direction of the centrifugal force on the rider?  
 (a) 180N, radially outward (b) 180N, radially inward (c) 80N, radially outward (d) 20N, radially outward.
43. Nuclear reactions like fission and fusion can generate huge amount of energy from the mass loss in the reactions, defined by Einstein's equation,  $E=mc^2$ . If the released energy of two hydrogen atoms  ${}^1_1H$  and two neutrons fused into a helium  ${}^4_2He$  is  $4.544 \times 10^{-12}$  J, what is the binding energy per nucleon in  ${}^4_2He$ ? Given  $1 \text{ MeV} = 1.6 \times 10^{-13}$  J, the mass per nucleon  $\approx 1800m_e$ , and electron rest energy  $\approx 0.51 \text{ MeV}$ .  
 (a) 6.08 (b) 7.1 (c) 14.2 (d) 27.38 (e) 28.4 MeV.
44. One hundred milliliters of water are poured into a U-tube which has a cross-sectional area of  $1.0 \text{ cm}^2$ . One hundred milliliters of oil, which has a density 0.80 that of water, are then poured down one side of the U-tube so that the oil floats on the water. Find the difference in height of the liquid surfaces in the two sides of the U-tube.  
 (a) 10cm (b) 20cm (c) 30cm (d) 40cm.
45. A 1.37 M aqueous solution of citric acid ( $H_3C_6H_5O_7$ ) has a density of  $1.10 \text{ g/cm}^3$ . What is the mole fraction of the citric acid?  
 (a) 0.012 (b) 0.028 (c) 0.035 (d) 0.15 (e) 0.20.

46. A cat runs across a parking lot on which a set of coordinate axes has been drawn. The coordinates (meters) of the rabbit's position as functions of time  $t$  (seconds) are given by  $x(t) = -0.31t^2 + 7.2t + 28$  and  $y(t) = 0.22t - 9.1t + 30$ . Please find the magnitude of velocity at time  $t = 15$  s.  
(a) 2.3 m/s      (b) 3.3 m/s      (c) 4.3 m/s      (d) 5.3 m/s.
47. What is a weight percent of solutes in the following solution: 25 g  $\text{NaHCO}_3(s)$  dissolved in 100 g of water?  
(a) 25%.      (b) 5%.      (c) 20%.      (d) 10%.      (e) 30%.
48. The electric field due to a uniform distribution of charge on a spherical shell is zero:  
(a) everywhere      (b) only at the center of the shell      (c) only outside the shell      (d) only inside the shell.
49. A zinc-copper battery is constructed as  $\text{Zn}|\text{Zn}^{2+} (0.1 \text{ M})||\text{Cu}^{2+} (2.0 \text{ M})|\text{Cu}$ . The mass of Zn and Cu electrode is 200 g and 100 g, respectively. Calculate the mass of Cu electrode after 5.0 A of current has flowed for 5h. The atomic mass for Cu is 63.546.  
(a) 100 g      (b) 40 g      (c) 70 g      (d) 160 g      (e) 130 g.
50. A model airplane whose mass is 0.75kg is tethered by a wire so that it flies in a circle 30m in radius. The airplane engine provides a thrust of 0.80N perpendicular to the tethering wire. Find the torque the engine thrust produces about the center of the circle.  
(a) 48Nm      (b) 36Nm      (c) 24Nm      (d) 12Nm.