國立成功大學 108 學年度碩士班招生考試試題

系　　所：材料科學及工程學系

考試科目：物理與化學

考試日期：0223，節次：1

※ 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. Which of the following was proposed by Maxwell?
   (a) a changing electric field has a magnetic field associated with it
   (b) a static magnetic field induces a current
   (c) a changing magnetic field induces a current
   (d) none of the above is correct.

2. What is the most likely bond in molecules?
   (a) purely covalent
   (b) purely ionic
   (c) ones in which the atoms share electrons to an unequal extent
   (d) ones in which the atoms share electrons to an equal extent.

3. When a particle's energy is smaller than its potential energy, then the particle has
   (a) a great possibility　(b) no possibility　(c) a very small possibility　(d) 50% of possibility to penetrate the potential wall.

4. Which of the following can be used to explain Bohr's orbital stability condition?
   (a) $\lambda = 2\pi r$　(b) $n\lambda = 2\pi r$　(c) $n\lambda = \pi r$　(d) $\lambda = \pi\rho$

5. According to de Broglie, a moving particle is associated with a wavelength, λ. Does this mean that
   (a) only electron sized　(b) only atomic sized　(c) only charged particles　(d) all particles have a wavelength?

6. For a thin rectangular plate with dimension a*b with thickness t and mass M , the axis is through the center and perpendicular to the plate, what is the moment of inertia of this plate about the axis?
   (a) $\frac{1}{2}M(a^2+b^2)$　(b) $\frac{1}{4}M^2(a+b)$　(c) $\frac{1}{6}M(a^2+b^2)$　(d) $\frac{1}{12}M(a^2+b^2)$

7. A steel piano wire 1.12m long has a cross sectional area of $6\times10^{-3}cm^2$. The Young's modulus is $20.6\times10^{10}N/m^2$. When under a tension of 115N, how much does it stretch?
   (a) 1.04 mm　(b) 0.104 μm　(c) 0.962 mm　(d) 0.0962 μm

8. Poisson's ratio is a measure of the **Poisson effect**, the phenomenon in which a material tends to expand in directions perpendicular to the direction of compression. The Poisson's ratio of a stable, isotropic, linear elastic material will be greater than *a* or less than *b*. What is (*a*, *b*)?
   (a) (0, 0.5)　(b) (-0.5, 0.5)　(c) (-1, 0.5)　(d) (0, 1)

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9. A billiard ball of radius R rests on a frictionless, horizontal surface. The ball is struck a horizontal blow a distance *h* above the surface. For what value of *h* will there be no tendency for the ball to slip as it begins to roll? (Hint: The linear impulse $F\Delta t$ gives to the center of mass (CM) a change in momentum $m\Delta v$; correspondingly, the angular impulse about the CM produces a change in the angular momentum about the CM. What is the relation between these effects so that these will be no slipping?)

(a) R　(b) 1.2R　(c) 1.4R　(d) 1.6R

10. A ball on the end of a cord swings in a horizontal circle of radius r=0.60m while the cord makes the angle of 35 degrees with respect to the vertical. Find the time required for the ball to make one revolution.

(a) 2.03s　(b) 1.86s　(c) 0.52s　(d) 0.49s

11. An ink drop with a mass m of 1.3×10^{-10} kg and a negative charge of magnitude Q = 1.5×10^{-13} C enters the region between the plates, initially moving along the x axis with speed Vx = 18 m/s. The length L of each plate is 1.6 cm. The plates are charged and thus produce an electric field at all points between them. Assume that field E is downward directed (-z direction), is uniform, and has a magnitude of 1.4×10^{6} N/C. What is the vertical deflection (z direction) of the drop at the far edge of the plates? (Neglect gravitational force and edge effects.)

(a) +0.64 mm　(b) -0.64 mm　(c) +1.28 mm　(d) -1.28 mm

12. A sphere of radius R with a uniform volume charge density ρ, please find the magnitude of electric field at r (r<R).

(a) $\frac{\rho r^3}{3\varepsilon_o R^2}$　(b) $\frac{\rho R^3}{3\varepsilon_o r^2}$　(c) $\frac{\rho R}{3\varepsilon_o}$　(d) $\frac{\rho r}{3\varepsilon_o}$

13. The electric potential at any point on the central axis of a uniformly charged disk is $V=\frac{\sigma}{2\varepsilon_0}\left(\sqrt{z^2+R^2}-z\right)$ where z is the vertical distance from disk center and R is the radius of the disk. Please find the electric field at any point on the axis of the disk.

(a) $\frac{\sigma}{2\varepsilon_0}\left(-1+\frac{z}{\sqrt{z^2+R^2}}\right)$　(b) $\frac{\sigma}{2\varepsilon_0}\left(1-\frac{z}{\sqrt{z^2+R^2}}\right)$　(c) $\frac{\sigma}{2\varepsilon_0}\left(1-\frac{R}{\sqrt{z^2+R^2}}\right)$　(d) $\frac{\sigma}{2\varepsilon_0}\left(-1+\frac{R}{\sqrt{z^2+R^2}}\right)$

14. Capacitor 1 with C_1=3.55 μF is charged to a potential difference V_0 = 6.30 V, using a 6.30 V battery. The battery is then removed, and the capacitor is connected to an uncharged capacitor 2, with C_2 = 8.95 μF. When switch is closed, charge flows between the capacitors. Find the charge on each capacitor when equilibrium is reached.

(a) $q_1 = 6.35\,\mu C,\ q_2 = 16.0\,\mu C$　(b) $q_1 = 16.0\,\mu C,\ q_2 = 6.35\,\mu C$

(c) $q_1 = 6.35\,\mu C,\ q_2 = 6.35\,\mu C$　(d) $q_1 = 16.0\,\mu C,\ q_2 = 16.0\,\mu C$

15. A parallel-plate capacitor of plate area A and plate separation d. A potential difference V_0 is applied between the plates by connecting a battery between them. The battery is then disconnected, and a dielectric slab of thickness b and dielectric constant k is placed at the middle of the plate gap. Assume A = 115 cm^2, d = 1.24 cm, V_0 = 85.5 V, b = 0.780 cm, and k = 2.61. What is the electric field in the gaps between the plates and the dielectric slab?
(a) 6.90 kV/m (b) 5.38 kV/m (c) 4.50 kV/m (d) 2.64 kV/m

16. A gas has a volume of 2.0 L, a temperature of 27 °C, and a pressure of 1.0 atm. When the gas is heated to 57 °C and compressed to a volume of 1.0 L, what is its new pressure?
(a) 1.2 atm (b) 2.2 atm (c) 3.2 atm (d) 4.2 atm

17. The average energy associated with the motion in one direction (e.g. x-axis) is: (here, k is the Boltzmann's constant, T is the absolute temperature)
(a) kT/2 (b) kT (c) 3kT/2 (d) 2kT

18. A vessel holds an equal number of moles of helium and methane (CH_4). The ratio of the rms speeds of the helium atoms to CH_4 molecules is:
(a) 1 (b) 2 (c) 4 (d) 16

19. If the temperature of an ideal gas is doubled while maintaining constant pressure, the average speed of the molecules:
(a) remains constant. (b) increases by a factor of 4.
(c) increases by a factor of 2. (d) increases by a factor of $\sqrt{2}$.

20. The average translational kinetic energy of the molecules of an ideal gas depends on:
(a) the number of moles of the gas and its temperature.
(b) the pressure of the gas and its temperature.
(c) the temperature of the gas only.
(d) the pressure of the gas only.

21. The electric field in the region between a pair of oppositely charged plane parallel plates, each 100 cm^2 in area, is 10^4 $N.C^{-1}$. What is the charge on each plate? Neglect edge effects.
(a) 8.85×10^{-9} C (b) 8.85×10^{-10} C (c) 8.75×10^{-10} C (d) 8.75×10^{-9} C

22. The potential at a certain distance from a point charge is 600 V, and the electric field is 200 $N.C^{-1}$. What is the magnitude of the charge?
(a) 0.2×10^{-6} C (b) 0.3×10^{-6} C (c) 0.4×10^{-6} C (d) 0.6×10^{-6} C

23. The open-circuit terminal voltage of a source is 10 V and its short-circuit current is 4.0 A. What will be the current when the source is connected to a linear resistor of resistance 2 Ω?
(a) 2 A (b) 2.5 A (c) 2.2 A (d) 2.22 A

24. A singly charged Li^7 ion has a mass of 1.16×10^{-23} g. It is accelerated through a potential difference of 500 V and then enters a magnetic field of 0.4 T, moving perpendicular to the field. What is the radius of its path in the magnetic field?
(a) 2.10×10^{-2} m (b) 2.11×10^{-2} m (c) 2.12×10^{-2} m (d) 2.13×10^{-2} m

25. A solenoid is to be designed to produce a magnetic field of 0.1 T at its center. The radius is to be 5 cm and the length 50 cm, and the available wire can carry a maximum current of 10 A. What total length of wire is required?
(a) 1.25 m (b) 12.5 m (c) 125 m (d) 1250 m

26. Which of the following molecules has polar bonds but no resulting dipole moment,
(a) CO_2 (b) HF (c) H_2O (d) O_2

27. For the formation of ionic compound,
(a) both nonmetal and metal atoms attain noble gas electron configuration.
(b) the valence orbitals of the nonmetal are emptied.
(c) the valence electron configuration of the metal is completed.
(d) metal and nonmetal share electrons in a way that completes the valence electron configurations of both atoms.

28. For the isoelectronic ions,
(a) F^- is larger than O^{2-}. (b) the ions with more protons are bigger.
(c) the number of valence electrons is the same. (d) the size decreases as the nuclear charge increases.

29. Sometimes more than one valid Lewis structures is possible for a given molecules,
(a) because the exceptions to the Octet rule are there.
(b) because some electrons are delocalized and able to move around the entire molecule.
(c) because valence electrons are shared between a given pair of atoms.
(d) because more than one valence electrons of atoms can be shared via chemical bonding.

30. As the equilibrium of the system is reached without chemical reaction,
(a) the system has the lowest Gibbs free energy.
(b) the system is stabilized by the contribution of entropy.
(c) the concentrations of all reactants remain constant with time.
(d) the system is stable.

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31. In a voltaic cell, current is driven out of the two electrodes by spontaneous chemical reactions. Which one of the following phenomena appear on the interface of the negatively charged electrode?
(a) oxidation (b) reduction (c) attracting anions (d) relatively rich cations

32. In a voltaic cell, current is driven out of the two electrodes by spontaneous chemical reactions. Which one of the following phenomena appear on the interface of the positively charged electrode?
(a) attracting cations (b) reduction (c) oxidation (d) relatively rich anions

33. Refer to the reduction potentials of Fe^{2+}/Fe (-0.440V), Fe^{3+}/Fe^{2+} (0.771V), Mg^{2+}/Mg (-2.37V), Ti^{2+}/Ti (-1.63V), Cr^{3+}/Cr (-0.744V), Cu/Cu^{+} (0.337V). Which one of the following metals cannot be applied for cathodic protection to prevent metal iron from oxidation?
(a) Magnesium (b) Titanium (c) Chromium (d) Copper

34. Work can be generated in an electrochemical cell or a battery. Which one of the following cells may generate the most work?
(a) $Zn + 2MnO_2 \rightarrow ZnO + H_2O + Mn_2O_3$ $\quad E^o_{cell} = 1.50V$
(b) $Mg + 2H^+ \rightarrow H_2 + Mg^{2+}$ $\quad E^o_{cell} = 2.36V$
(c) $Pb + PbO_2 + 2HSO_4^- + 2H^+ \rightarrow 2PbSO_4 + 2H_2O$ $\quad E^o_{cell} = 2.10V$
(d) $5Fe + 2MnO_4^- + 16H^+ \rightarrow 5Fe^{2+} + 2Mn^{2+} + 8H_2O$ $\quad E^o_{cell} = 1.95V$

35. As a treasure hunter, you found a sunken wooden chest in the ocean, where contains ancient gold and silver coins. The hundreds year old silver coins have been seriously corroded by marine materials. By your best guess, what corrosion and mineral materials can be found on the silver surface? **Note:** Seawater has very different gas composition other than air and please think about group 6A elements, ocean pH≈ 8.2, the degraded wooden chest, and marine shells as the clues for your answer.
(a) silver sulfide and calcium sulfate (b) silver oxide and calcium hydroxide
(c) silver sulfide and calcium carbonate (d) silver oxide and calcium oxide.

36. Please identify the chemical formula of aluminum oxide.
(a) Al_2O_3 (b) Al_3O_2 (c) AlO (d) AlO_2

37. Please identify the formula of a compound formed between Ga and Br.
(a) Ga_3Br (b) $GaBr_3$ (c) $GaBr_2$ (d) $GaBr_4$

38. Which of the following metals will substitute lead from $Pb(NO_3)_2$?
(a) Na (b) Al (c) Zn (d) Ti

39. The yellow light emitted by a sodium lamp has a wavelength of 600 nm. What is the frequency of this radiation? (Hint: the speed of light is 3×10^8 m/sec).
(a) 1×10^{14} Hz (b) 5×10^{13} Hz (c) 5×10^{15} Hz (d) 5×10^{14} Hz

40. What is the characteristic wavelength of an electron with a velocity of 7×10^6 m/s? (Hint: the mass of the electron is 9×10^{-28}g; Planck's constant is 6.6×10^{-34}J-s).
(a) 10^{-10} m (b) 10^{-8} m (c) 10^{-11} m (d) 10^{-12} m

41. Which of these species is probably the weakest acid ?
(a) HCl (b) H_3PO_4 (c) $H_2PO_4^-$ (d) HPO_4^{2-}

42. According to the Lewis theory, a base _____ .
(a) is a proton acceptor. (b) is a proton donor.
(c) makes available a share in a pair of electrons. (d) produces OH^- ions in aqueous solution.

43. Give the IUPAC name of this compound: $CH_3OCH_2CH_3$.
(a) dimethyl ether (b) methoxyethane (c) methylethyloxide (d) propyl ether

44. What volume of 12.6 M HCl must be added to enough water to prepare 5.00 liters of 3.00 M HCl?
(a) 1.19 L (b) 21.0 L (c) 0.840 L (d) 7.56 L

45. What volume of 0.50 M KOH would be required to neutralize completely 500 mL of 0.25 M H_3PO_4 solution?
(a) 2.5×10^2 mL (b) 1.4×10^3 mL (c) 5.2×10^2 mL (d) 7.5×10^2 mL

46. The Nobel Prize in Chemistry 2018 was awarded to F.H. Arnold, G.P. Smith, and G.P. Winter for their contributions related NOT to
(a) enzymes (b) conjugated polymers (c) peptides (d) antibodies

47. What is defined by a substance as the amount of heat required to raise the temperature of 1 mol of the substance for 1 °C?
(a) heat capacity (b) heat diffusivity (c) heat conductivity (d) heat resistance

48. When 2.96g of HgCl is vaporized in a 1L bulk at 680 K, the pressure is 458 torr. What are the molecular weight and molecular formula of HgCl vapor?
(a) 244 g/mol (b) 254 g/mol (c) 264 g/mol (d) 274 g/mol

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49. A solution that produces ions when dissolved in water is called:

(a) electrolysis　(b) electrolyte　(c) dialysis　(d) hydrolysis

50. The vapor pressure of benzene at 25 °C is 94.7 torr. After 1.0 g of benzene is injected into a 10L bulb held at 25 °C , what is the partial pressure of benzene in the bulk?

(a) 28.8 torr　(b) 57.6 torr　(c) 47.4 torr　(d) 94.7 torr