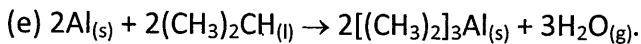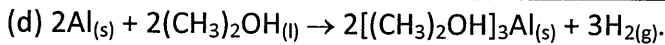※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

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. For doping in a covalently-bonded silicon, which one of the following elements shall have the smallest excitation energy in silicon? (a) Nitrogen (b) Phosphor (c) Arsenic (d) Antimony (e) Bismuth

2. At standard condition, 25 $^{\circ}$C and 1 atm per mole, which one of the following reactions will give $\Delta S_0 > 0$? S_0 denotes the entropy of materials in standard condition. (a) $H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)}$ (b) $CS_{2(g)} + 3O_{2(g)} \rightarrow CO_{2(g)} + 2SO_{2(g)}$ (c) $3O_{2(g)} \rightarrow 2O_{3(g)}$ (d) $Al_2O_{3(s)} + 3H_{2(g)} \rightarrow 2Al_{(s)} + 3H_2O_{(g)}$ (e) $2Al_{(s)} + 3Br_{2(l)} \rightarrow 2AlBr_{3(s)}$

3. For real gases, we can approximate their non-ideal behaviors by van der Waals fluid equation, $[P + a(n/V)^2](V - nb) = nRT$, a and b are constants. For methane, ethane, propane, butane, and pentane with the same moles in the same piston, which gas do you expect to provide the largest pressure for its condensation? (a) Methane (b) Ethane (c) Propane (d) Butane (e) Pentane

4. Which of the following descriptions about the polarization is wrong? (a) Normally larger atoms are more difficult to be polarized. (b) It is related to the distortion of electron cloud. (c) It is influenced by electronegativity of bonded atoms. (d) Cations become smaller, more highly charged, and hence more strongly polarizing, from left to right across a periodic table.

5. How many mL of 17 M NH_3 must be diluted to 500.0 mL to make a 0.75 M solution? (a) 13 mL (b) 22 mL (c) 39 mL (d) 73 mL

6. C_2H_5OH and CH_3COCH_3 are all colorless liquid, they could be distinguished using (a) FTIR, (b) ^{1}H-NMR, (c) Mass spectrometry, (d) UV-vis, (e) all of the above.

7. The standard electrode potential (E^0) in aqueous solutions at 25°C:

$Li^+ + e- \rightleftharpoons Li$	$E^0 = -3.05$
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	$E^0 = 1.92$
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	$E^0 = -2.84$
$O_2 + 4H^+ + 4e^- \rightleftharpoons H_2O$	$E^0 = 1.23$
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	$E^0 = 0.15$

Which of the following has least strength as a reducing agent?　(a) Li (b) Co^{2+} (c) Ca (d) H_2O (e) Sn^{2+}

8. Please identify the potential equation for the following chemical reaction: the formation of a metal alkoxide resulted from a reaction of aluminum with isopropyl alcohol.

(a) $2Al_{(s)} + 2(CH_3)_2CHOH_{(l)} \rightarrow 2[(CH_3)_2CHO]_3Al_{(s)} + 2H_{2(g)}$.

(b) $2Al_{(s)} + 2(CH_3)_2CHOH_{(l)} \rightarrow 2[(CH_3)_2CHO]_3Al_{(s)} + 3H_{2(g)}$.

(c) $Al_{(s)} + (CH_3)_2CHOH_{(l)} \rightarrow [(CH_3)_2CHO]_3Al_{(s)} + H_2O_{(g)}$.

(d) $2Al_{(s)} + 2(CH_3)_2OH_{(l)} \rightarrow 2[(CH_3)_2OH]_3Al_{(s)} + 3H_{2(g)}$.

(e) $2Al_{(s)} + 2(CH_3)_2CH_{(l)} \rightarrow 2[(CH_3)_2]_3Al_{(s)} + 3H_2O_{(g)}$.

9. Please predict whether the following molecules, BrCl, SO_2, and SF_6, are polar or nopolar. (a) Polar, polar, and nonpolar. (b) Polar, nonpolar, and polar. (c) Polar, nopolar, and nonpolar. (d) Polar, polar, and polar. (e) Nopolar, nopolar, and nonpolar.

10. Calculate ΔG^o for the reaction $Cu^{2+}_{(aq)} + Fe_{(s)} \rightarrow Cu_{(s)} + Fe^{2+}_{(aq)}$; given $Cu^{2+} + 2e^- \rightarrow Cu$ (E^o=0.34 V), and $Fe^{2+}+2e^- \rightarrow Fe$ (E^o = -0.44 V); (a) 1.5×10^5 J (b) -1.5×10^5 J (c) -7.5×10^4 J (d) -7.5×10^5 J (e) -3.0×10^5 J

11. Diamond is the hardest naturally occurring substance because the structure is stabilized by (a) covalent bonds (b) metallic bonds (c) ionic bonds (d) van der Waal force (e) none of above

12. Enthalpy changes for a chemical reaction are extremely important in thermochemistry. If the enthalpy content of the products of a reaction is less than that of the reactants, what kind of reaction of this? (a) heat absorption (b) endothermic (c) exothermic (d) desorption (e) no heat change

13. Given that the Activity Series is: Na>Mg>Cu>Ag>Au, which one of the following answers represents the ions that would not be displaced from aqueous solution (reduced) by metallic magnesium? (a) Na^+　(b) Cu^{2+} (c) Cu^{2+} and Au^+　(d)　Cu^{2+}, Ag^+ and Au^+

14. For the electronegativity, (a) it measures the pulling power of an atom on surrounding free electrons in vacuum. (b) it explains the formation of a polar covalent bond between two atoms with partial electric charges. (c) it explains the formation of ions. (d) it tends to increase toward the upper-left corner of periodic table and decrease toward the lower right corner.

15. For the early experiments able to characterize the atom, which of the following descriptions is correct? (a) The cathode ray is repelled by the positive pole of an applied electric field. (b) From the deflection of cathode ray in a magnetic field, J. J. Thomson determined the charge-to-mass ratio of an electron. (c) As the fall of charged oil droplets due to gravity can be halted by adjusting the voltage of applied electric field, Robert Millikan is able to calculate the mass of an oil drop in 1909. (d) Rutherford's experiment on α-particle bombardment of metal foil leads to the discovery of a dense neutral center of atom called the nucleus.

16. Indicate formal charge of S in the following structure.

$$\left[\begin{array}{c} \ddot{O} \\ | \\ \ddot{O}-S-\ddot{O} \\ | \\ \ddot{O} \end{array} \right]^{2-}$$
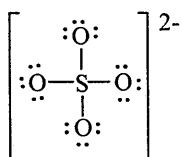
(a) +2, (b) -2, (c) 0, (d) +4, (e) +3.

17. Boiling point of sodium chloride (NaCl) is higher than 1,400 °C. However, NaCl could be dissolved in

water at room temperature, it is due to (a) catalyst, (b) decomposition, (c) solvation, (d) decoupling, (e) esterification.

18. Calculate the mass of ethylene glycol ($C_2H_6O_2$) required in 5 L of water to produce an antifreeze solution with a freezing point of -20°C? The depression constant for ethylene glycol is 1.86 (°C kg/mol) and assume the density of water is 1 g/mL. (a) 1.5 kg (b) 2.4 kg (c) 2.7 kg (d) 4.2 kg (e) 3.3 kg

19. A 2.5-g sample of ground water contain 5.0 micrograms of Zn^{2+}. What is the concentration of Zn^{2+} in parts per million (ppm)? (a) 2×10^{-6}. (b) 0.5. (c) 0.03. (d) 2. (e) 36.

20. For the following descriptions of reversible processes, which one is NOT correlated? (a) All real processes are irreversible (b) The maximum work obtainable from the gas occurs when the expansion is carried out reversibly (c) Any energy wastes will provoke the failure of obtaining the maximum work (d) The ΔG (free energy of a reaction) is always greater than 0 (e) Throughout the entire reversible process, the system is in thermodynamic equilibrium with its surroundings

21. An unknown organic compound reacts with 6.25 mole of air. After fully consuming the organic compound, 33 g of CO_2 and 18 g H_2O are produced. Please find the organic compound (a) CH_4 (b) C_2H_2 (c) C_3H_8 (d) C_2H_6 (e) C_2H_5OH

22. Which of the following description about the solubility of salt in water is wrong? (a) Most nitrate (NO_3^-) salts are quite soluble. (b) Most salts of Na^+ are quite soluble. (c) Most hydroxide salts are quite soluble. (d) Most sulfide (S^{2-}), carbonate (CO_3^{2-}), and phosphate (PO_4^-) salts are only slightly soluble.

23. Ion is used to reduce antimony in sulfide ores:

$$Sb_2S_3(s) + 3Fe(s) \longrightarrow 2Sb(s) + 3SFe(s) \qquad \Delta H = -125KJ$$
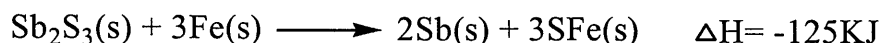
Calculate ΔS_{surr} for the reaction at 25 °C and 1 atm.　ΔS_{surr} = (a) 350, (b) 230, (c) 419, (d) 250, (e) 280 J/K.

24. What is the pH of 2×10^{-2} M KOH solution? (a) 12.3 (b) 13.1 (c) 10.7 (d) 1.7 (e) 7.0

25. If the half-life for a reaction is 20 seconds, what would be the second half-life for a second order reaction? (a)10 (b)20 (c)30 (d)40 (e)50

26. Two waves of the same frequency have amplitudes 1.00 and 2.00. They interfere at a point where their phase difference is 60.0°.　What is the resultant amplitude? (a) 3.5 (b) 2.65 (c) 3 (d) 5 (e) 5.25

27. A spaceship, moving away from Earth at a speed of 0.900c, reports back by transmitting at a frequency (measured in the spaceship frame) of 100 MHz. To what frequency must Earth receivers be tuned to receive the report? (a) 100 MHz (b) 9 MHz (c) 1.8 MHz (d) 18.9 MHz (e) 22.9 MHz

28. A rigid rod of length 1m and negligible mass is pivoted at one end about a vertical axis so that it rotates

freely in a horizontal plane.　A 0.4-kg mass is attached to the free end.　A horizontal force of 5N is applied perpendicularly to the rod at its midpoint.　**Starting at rest, through how many radians will it turn in 4-s?** (the force is always perpendicular to the rod) (a)12.5rad (b)25rad (c)37.5rad (d)50rad.

29. A driving force causes a damped oscillator to undergo the following (steady-state) displacement as a function of time:　$x = A\sin\omega t$.　If the resistive force is $-bv$, find how much work is done against the resistive force during one complete cycle of the motion.　(a) $2\pi bA^2\omega/3$　(b) $\pi bA^2\omega/2$　(c) $\pi bA^2\omega$　(d) $3\pi bA^2\omega/4$.

30. What is the fundamental principle to derive Bragg's Law (a) the standing waves (b) the traveling waves (c) the scattering waves (d) the interference waves

31. For an ohmic substance, the resistivity depends on: (a) the electron mean free time (b) the electric field (c) the current density (d) the potential difference

32. Air is pumped into a bicycle tire at constant temperature. The pressure increases because: (a) more molecules strike the tire wall per second (b) the molecules are farther apart (c) each molecule is moving faster (d) each molecule has more kinetic energy

33. In the below figure, initially unpolarized light is sent into a system of three polarizing sheets whose polarizing directions make angles of $\theta_1 = 40°$, $\theta_2 = 20°$, and $\theta_3 = 40°$ with the direction of the y axis. What percentage of the light's initial intensity is transmitted by the system? (a) 3.0% (b) 3.1% (c) 3.2% (d) 3.3%
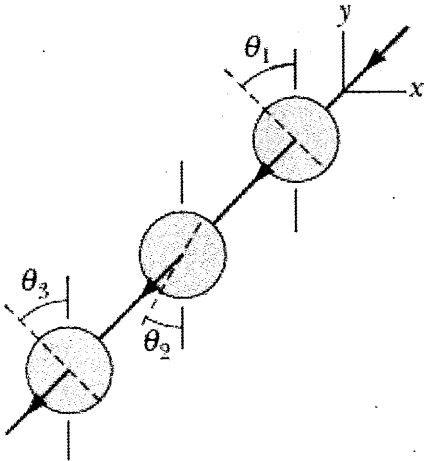

34. An electron enters a uniform magnetic field B=0.28 T at a 45° angle to to magnetic field.　Determine the radius r of the electron's helical path assuming its speed is 3.06 ×10^6 m/s. Mass of one electron is 9.11×10^{-31} kg.　(a) 4.3×10^{-1} m (b) 4.3×10^{-3} m　(c) 4.3×10^{-5} m　(d) 4.3×10^{-7} m
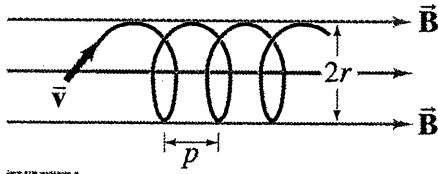
35. What is the resistance of a 4.5-m length of copper wire 1.5 mm in diameter? Copper resistance coefficient is 1.6×10^{-8} Ωm. (a) 1.6×10^{-8} Ω (b) 4.3×10^{-2} Ω (c) 1.6×10^{2} Ω (d) 4.3×10^{6} Ω

36. If the azimuthal wave function for the hydrogen atom is $\Phi(\varphi) = A e^{1 m_l \varphi}$, then the value of the normalized constant is (a) $\frac{1}{\sqrt{2\pi}}$ (b) $\sqrt{2\pi}$ (c) $\frac{1}{\sqrt{\pi}}$ (d) $\sqrt{\pi}$ (e) $\frac{2}{\sqrt{\pi}}$

37. How does the quantum mechanical model describe electrons as? (a) Particles (b) Waves (c) Hard spheres (d) Particles with wave-like properties (e) Maxwell particles.

38. In consideration of the Gauss law for magnetic field, if the medium is considered to be air, which of the following equation is true ? (a) Curl(H) = 0 (b) Grad(H) = 0 (c) Div(H) = 0 (d) Div(H) = 1.

39. The Maxwell second equation that is valid in any conductor is which of the following? (a) Curl(H) = Jc (b) Curl(E) = Jc (c) Curl(E) = Jd (d) Curl(H) = Jd.

40. In the consideration of the theoretical derivation in the electromagnetic theory, which of the following would be the solution when two vectors are perpendicular? (a) Dot product is zero (b) Cross product is zero (c) Both are zero (d) Both are not necessarily zero.

41. In the laser operation pumped by optical absorption, what is the minimum number of energy levels needed in order to achieve population inversion? (a) 1 (b) 2 (c) 3 (d) 4

42. The maximum wavelength for photoelectric emission in a metal is 115 nm. What wavelength of the UV light is needed to generate photoelectrons with the maximum kinetic energy up to 3.0 eV? (a) 100 nm (b) 90 nm (c) 80 nm (d) 70 nm

43. X rays of wavelength 0.12 nm are found to undergo second- order reflection at a Bragg angle of 28° from a lithium fluoride crystal. What is the interplanar spacing of the reflecting planes in the crystal? (a) 0.33 nm (b) 0.9 nm (c) 0.66 nm (d) 0.52 nm (e) 0.26 nm

44. A string fixed at both ends is 8.0 m long and has a mass of 0.120 kg. It is subjected to a tension of 96.0 N and set oscil-lating. Calculate the speed of the waves on the string, ν, and the longest possible wavelength for a standing wave,? (a) ν =80.00 m/s; λ =8.0 m (b) ν =11.52 m/s; λ =8.0 m (c) ν =80.00 m/s; λ =16.0 m (d) ν =12.00 m/s; λ =8.0 m (e) ν =40.00 m/s; λ =16.0 m

45. A laser is travelling at the speed of 0.6c (c is speed of light) and emits light in the direction of its motion. What is the speed of the emitted light in the reference frame in which the laser is travelling? (a) 0.3c

(b) 0.6c　　(c) 0.4c　　(d) 1.6c

46. 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

47. If an electric wire is allowed to produce a magnetic field no larger than that of the Earth 0.5×10^{-4}T at a distance of 15 cm from the wire, what is the maximum current the wire can carry? (We assume that the wire is long and straight. Permeability in Vacuum = 4π×10^{-7} Tm/A.) (a) 0.38A (b) 3.8 A (c) 38 A (d) 380 A

48. The below figure shows four long horizontal layers A–D of different materials, with air above and below them. The index of refraction of each material is given. Rays of light are sent into the left end of each layer as shown. In which layer is there the possibility of totally trapping the light in that layer so that, after many reflections, all the light reaches the right end of the layer? (a) A, D (b) B (c) C (d) none
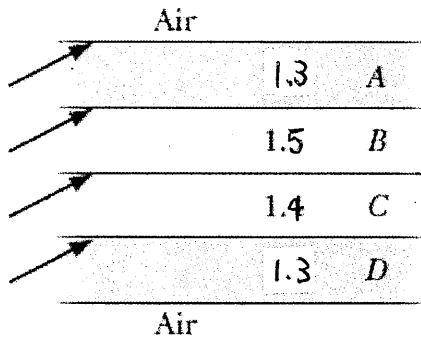
49. A block of wood (specific gravity=0.70) is 40cm long, 20cm wide, and 5cm thick.　What volume of lead (specific gravity=11.35), fastened to the bottom, will cause the wood to sink in water so that its top is barely even with the water surface? (a) 29 cm^3 (b) 58 cm^3　(c) 116 cm^3 (d)232 cm^3 .

50. An asteroid, headed directly toward Earth, has a speed of v_i (km/s) and mass of m (kg), relative to the planet when the asteroid is n Earth radii from Earth's center. Neglecting the effects of Earth's atmosphere on the asteroid, find the asteroid's speed when it reaches Earth's surface. Earth's radius is R_E (m). Earth's gravitational constant is G $(m^3/kg \cdot s^2)$. Earth's mass is M_E (kg). (a)

$$\sqrt{m^2 v_i^2 + \frac{2GM}{R_E}\left(1 - \frac{1}{n}\right)} \text{ (b) } \sqrt{v_i^2 + \frac{2GM}{R_E}\left(1 - \frac{1}{n}\right)} \text{ (c) } \sqrt{m^2 v_i^2 + \frac{2GM}{R_E}\left(1 + \frac{1}{n}\right)} \text{ (d) } \sqrt{v_i^2 + \frac{2GM}{R_E}\left(1 + \frac{1}{n}\right)}$$