115學年度 學士後醫學系招生考試

物理及化學試題封面

考試開始鈴響前，請勿翻閱本試題！

★考試開始鈴響前，請注意：

一、除准考證、應考文具及一般手錶外；行動電話、穿戴式裝置及其他物品均須放在臨時置物區。

二、請務必確認行動電話已取出電池或關機，行動電話及手錶的鬧鈴功能必須關閉。

三、就座後，不可擅自離開座位或與其他考生交談。

四、坐定後，雙手離開桌面，確認座位號碼、答案卡號碼與准考證號碼相同，以及抽屜中、桌椅下或座位旁均無非考試必需用品。如有任何問題，請立即舉手反應。

五、考試開始鈴響前，不得翻閱試題本或作答。

六、考試全程不得吃東西、喝水及嚼食口香糖。

七、違反上述規定，依「筆試規則及違規處理辦法」議處。

★作答說明：

一、考試時間：100 分鐘。

二、本試題（含封面）共 **16** 頁，如有缺頁或毀損，應立即舉手請監試人員補發。

三、本試題共 90 題，皆為單選題，共計 150 分；每題答錯倒扣，不作答不計分。

四、答題依題號順序劃記在答案卡上，寫在試題本上無效；答案卡限用 2B 鉛筆劃記，若未按規定劃記，致電腦無法讀取者，考生自行負責。

五、試題本必須與答案卡一併繳回，不得攜出試場。

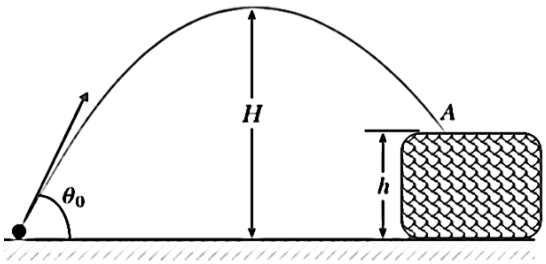
Choose one best answer for the following questions.

【單選題】每題 1 分，共計 30 分，答錯 1 題倒扣 0.25 分，倒扣至本大題零分為止，未作答，不給分亦不扣分。1~15 題為物理，16~30 題為化學。

1. A normal diastolic blood pressure is 80 mmHg. What is this pressure expressed in SI units (Système International d'Unités)? (Given: the density of mercury is 13.6 g/cm³ and the gravitational acceleration g = 10 m/s²)

   (A) 1.088×10^2 Pa (B) 1.088×10^3 Pa (C) 1.088×10^4 Pa
   (D) 1.088×10^5 Pa (E) 1.088×10^6 Pa

2. A ball is kicked from the ground with an initial speed of 50.0 m/s at an angle of $\theta_0 = 37^o$ above the horizontal. It lands on a roof (Point A) exactly 6.0 seconds after being kicked. Determine the speed of the ball just before it hits the roof. (Given: $\sin\theta_0$~0.6, $\cos\theta_0$~0.8, gravitational acceleration g = 10.0 m/s²)



   (A) 0.00 m/s (B) 36.1 m/s (C) 50.0 m/s (D) 72.2 m/s (E) 100 m/s

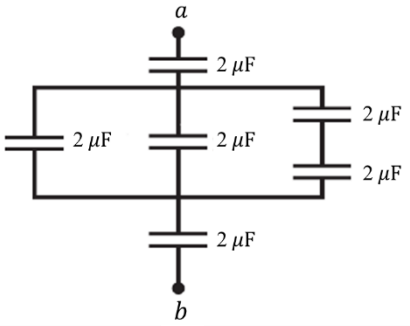
3. A particle moves along a vertical circular track of radius R. The circular track is smooth and has zero friction. The only forces acting on the particle are gravity and the normal force from the track. During its motion, the particle's maximum speed is 6/5 times its minimum speed. What is the minimum speed of the particle? (Gravitational acceleration g)

   (A) $\sqrt{6gR/5}$ (B) $\sqrt{10gR}$ (C) $\sqrt{20gR}$ (D) $\sqrt{50gR/11}$ (E) $\sqrt{100gR/11}$

4. Mary throws a ball with 0.80 kg mass against a brick wall. The ball is moving horizontally to the left at 30 m/s when it hits the wall; it rebounds horizontally to the right at 20 m/s. The ball is in contact with the wall for 0.010 s. Find the impulse of the net external force on the ball during its collision with the wall.

   (A) 40 N·m (B) 40 N·s (C) 8 N·m (D) 8 N·s (E) 800 J

5. Find the equivalent capacitance between a and b.



   (A) 0.83 μF (B) 1.2 μF (C) 2.4 μF (D) 6.0 μF (E) 12.0 μF

6. Incompressible oil with density ρ is pumped through a cylindrical pipe at a constant mass flow rate. The first section of the pipe has a diameter d_1 and flow speed v_1. The diameter of the second section of the pipe is twice that of the first section. What is the flow speed in the second section?

(A) $\frac{1}{4}v_1$ (B) $\frac{1}{2}v_1$ (C) v_1 (D) $2v_1$ (E) $4v_1$

7. Because the ear is sensitive over a broad range of intensities, a logarithmic measure of intensity called sound intensity level is often used. The chosen reference intensity I_0 is approximately the threshold of human hearing at 1000 Hz. If the intensity of a sound wave equals 10 I_0, what is the sound intensity level in dB?

(A) -3 (B) 1 (C) 3 (D) 10 (E) 20

8. If a simple pendulum oscillates with small amplitude and its length is doubled, what happens to the frequency of its motion?

(A) It doubles.
(B) It becomes $\sqrt{2}$ times as large.
(C) It becomes half as large.
(D) It becomes $1/\sqrt{2}$ times as large.
(E) It remains the same.

9. Two long straight wires are mounted parallel to each other, with one wire directly above the other. Each wire has a weight per unit length of w = 2.0×10^{-5} N/m. The separation between the wires is d = 0.080 m. The wires carry currents that are equal in magnitude but opposite in direction. Find the current I in each wire. (Given: permeability constant $\mu_0 = 4\pi \times 10^{-7}$ T·m/A)

(A) 1.8 A (B) 2.4 A (C) 2.8 A (D) 3.2 A (E) 3.6 A

10. An electric dipole with a dipole moment magnitude of $p = 5.0 \times 10^{-6}$ C·m is placed in a uniform electric field of magnitude $E = 2.0 \times 10^5$ N/C. The initial angle between the dipole moment $\vec{p}$ and the electric field $\vec{E}$ is 60^o. How much work must an external agent do to turn the dipole 180^o from its initial position?

(A) 0.5 J (B) 1.0 J (C) 1.5 J (D) 2.0 J (E) 0 J

11. Large aperture telescopes are used primarily to _____.

(A) collect more light
(B) reduce chromatic aberration
(C) increase magnification
(D) reduce diffraction limit
(E) decrease focal length

12. An electromagnetic wave with a peak magnetic field magnitude of 1.5×10^{-7} T has an associated peak electric field of what magnitude?

(A) 0.5×10^{-15} N/C (B) 2×10^{-5} N/C (C) 2.2×10^4 N/C
(D) 22 N/C (E) 45 N/C

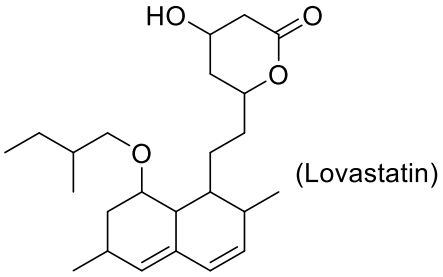
13. If Josh's face is 30.0 cm in front of a concave shaving mirror creating an upright image 1.50 times as large as the object, what is the mirror's focal length?
(A) 12.0 cm (B) 20.0 cm (C) 70.0 cm
(D) 90.0 cm (E) none of the above

14. What is the energy of each photon produced by positron–electron annihilation? (c is the speed of the light; m_o is the mass of electron at rest.)
(A) 12 $m_o c^2$ (B) 6 $m_o c^2$ (C) 2 $m_o c^2$ (D) $m_o c^2$ (E) $\frac{1}{2}\ m_o c^2$

15. When beryllium Be is bombarded by α particles, radiation X will be emitted from the target material. The nuclear reaction can be expressed as $\alpha + {}^{9}_{4}Be \rightarrow {}^{12}_{6}C + X$. What is radiation X?
(A) ${}^{1}_{1}n$ (B) ${}^{1}_{0}n$ (C) ${}^{1}_{1}p$ (D) ${}^{1}_{0}p$ (E) $\gamma - ray$

16. All of the following compounds are soluble in water **except** _____.
(A) NaCl (B) $CaCl_2$ (C) $FeCl_3$ (D) NH_4Cl (E) $PbCl_2$

17. How many stereogenic centers are there in Lovastatin (Mevacor®, a cholesterol-lowering drug)?



(Lovastatin)

(A) 4 (B) 5 (C) 6 (D) 7 (E) 8

18. Identify which of the following ions has the largest size.
(A) O^{2-} (B) F^{-} (C) Na^{+} (D) Mg^{2+} (E) Al^{3+}

19. Triethylamine [$(CH_3CH_2)_3N$] is a molecule in which the nitrogen atom is _____ hybridized and the CNC bond angle is _____.
(A) sp^2, >109.5° (B) sp^2, <109.5° (C) sp^3, >109.5°
(D) sp^3, <109.5° (E) sp, 109.5°

20. Rank the following elements in order of decreasing electronegativity.
I. C II. H III. Cl IV. Br V. Si
(A) I > II > III > IV > V (B) III > IV > I > II > V (C) III > IV > I > V > II
(D) III > IV > II > I > V (E) V > I > II > III > IV

21. Which of the following ions is paramagnetic?
(A) Cu^{+} (B) Zn^{2+} (C) O_2^{2-} (D) Cr^{3+} (E) Na^{+}

22. What is the number of nearest neighbors in a body-centered cubic lattice?
(A) 12 (B) 10 (C) 8 (D) 6 (E) 4

23. What is the coefficient of H_2O when the following reaction is balanced?
$MnO_4^-{}_{(aq)} + Fe_{(s)} + H^+{}_{(aq)} \rightarrow Fe^{2+}{}_{(aq)} + Mn^{2+}{}_{(aq)} + H_2O_{(l)}$ *unbalanced*
(A) 2 (B) 4 (C) 6 (D) 8 (E) 10

24. Based on the following half-reactions under standard conditions, which metal, Cu or Ni, could reduce Zn^{2+} to $Zn_{(s)}$ upon Cu or Ni mixed with a $Zn^{2+}{}_{(aq)}$ solution at ambient temperature?
$Zn^{2+} + 2e^- \rightarrow Zn$, $\varepsilon^\circ = -0.76$ V
$Cu^{2+} + 2e^- \rightarrow Cu$, $\varepsilon^\circ = 0.34$ V
$Ni^{2+} + 2e^- \rightarrow Ni$, $\varepsilon^\circ = -0.23$ V
(A) Both Ni and Cu would work. (B) Neither Ni nor Cu would work.
(C) Ni (D) Cu
(E) This cannot be determined.

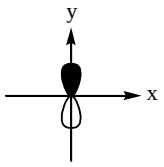
25. Determine the ΔS° that is expected to be positive for the following reactions.
(A) $H_2O_{(l)} \rightarrow H_2O_{(s)}$ (B) $2O_{2(g)} + 2SO_{(g)} \rightarrow 2SO_{3(g)}$
(C) $CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$ (D) $I_{2(g)} \rightarrow I_{2(s)}$
(E) none of the above

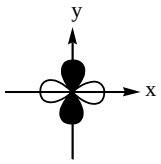
26. Which of the following species is weak electrolyte after dissolved in H_2O at ambient temperature?
(A) $C_{12}H_{22}O_{11(s)}$(sucrose) (B) $NH_{3(g)}$ (C) $KI_{(s)}$
(D) $H_2SO_{4(l)}$ (E) $NaCl_{(g)}$

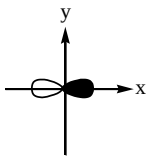
27. The hydrogen element occurs as three isotopes: ^1H, ^2H and ^3H. Which of the following statements is (are) **correct**?
I. Both ^1H and ^2H have stable nuclei; ^3H undergoes β decay.
II. ^2H solvents are used for NMR spectroscopy.
III. ^3H has 1 proton, 2 neutrons, and 1 electron.
(A) I and II (B) II and III (C) III (D) I and III (E) I, II, and III

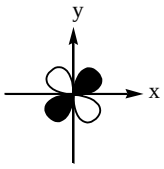
28. For the reaction $2N_2O_{(g)} \rightleftharpoons O_{2(g)} + 2\ N_{2(g)}$, what happens to the equilibrium position if the volume increases?
(A) shifts to the left (B) shifts to the right (C) does nothing
(D) doubles (E) halves

29. Which of following orbitals represents $3d_{xy}$?

(A) 

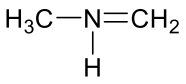
(B) 

(C) 

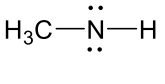
(D) 

(E) none of the above

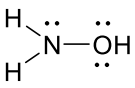
30. In which structure(s) below does nitrogen have a formal charge of +1?



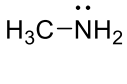
I



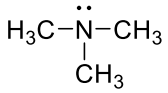
II



III



IV



V

(A) I (B) II and IV (C) III and V (D) I and V (E) V

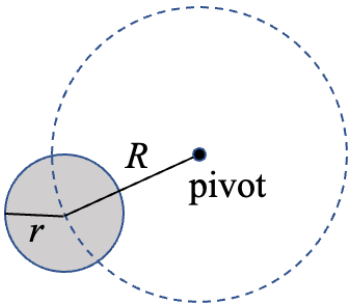
【單選題】每題 2 分，共計 120 分，答錯 1 題倒扣 0.5 分，倒扣至本大題零分為止，未作答，不給分亦不扣分。31~60 題為物理，61~90 題為化學。

31. A particle moves along the x-axis with an acceleration given by $a(t) = -kv^2$, where v is the instantaneous velocity and k is a positive constant. If the particle has an initial velocity v_0 at $x = 0$, what is the velocity as a function of position x?

(A) $v(x) = v_0 - kx$ (B) $v(x) = v_0 e^{-kx}$ (C) $v(x) = \sqrt{v_0^2 - 2kx}$

(D) $v(x) = v_0/(1 + kx)$ (E) $v(x) = v_0 - kx^2$

32. A uniform circular disk of mass M and radius r is connected by a light cord to a fixed pivot on a smooth horizontal table. The center of the disk moves at a constant distance R from the pivot and undergoes uniform circular motion with tangential speed v. The top view is as shown in the figure. The magnitude of the disk's angular momentum about the pivot is



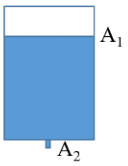
(A) MRv (B) $M\sqrt{(R^2 + r^2)}\,v$ (C) $M\sqrt{(R^2 + \frac{r^2}{2})}\,v$

(D) $M(R^2 + r^2)\frac{v}{R}$ (E) $M(R^2 + \frac{r^2}{2})\frac{v}{R}$

33. A 20 g bullet moving vertically upward at 1000 m/s strikes and passes through the center of mass of a 4.0 kg block initially at rest. The bullet emerges from the block moving directly upward at 400 m/s. Neglecting air resistance, to what maximum height does the block then rise above its initial position? (Gravitational acceleration g = 10 m/s^2)

(A) 0.3 cm (B) 2.1 cm (C) 15 cm (D) 30 cm (E) 45 cm

34. A water storage tank with cross-sectional area A_1 is filled to a height of h. The space above the water contains air at pressure $3p_0$. The water flows out the bottom of the tank through a short pipe with corss-sectional area A_2. The area A_1 is much larger than A_2. The pressure at the exit pipe is p_0. The water with density ρ is considered an ideal fluid. Find the flow speed in the pipe. (Gravitational acceleration g)



(A) $\sqrt{\frac{4p_o}{\rho}+2gh}$ (B) $\sqrt{\frac{3p_o}{\rho}+2gh}$ (C) $\sqrt{\frac{2p_o}{\rho}+2gh}$

(D) $\sqrt{\frac{p_o}{\rho}+2gh}$ (E) $\sqrt{2gh}$

35. In hydrotherapy training at KMU, a therapist measures a patient's body density using underwater weighing. A patient has a mass of 75.0 kg in air. When fully submerged in water, the apparent mass is 3.0 kg. Assume water density ρ = 1.0 g/cm^3 and neglect lung air volume changes. What is the patient's body density?

(A) 0.960 kg/m^3 (B) 1.042 kg/m^3 (C) 960 kg/m^3
(D) 1042 kg/m^3 (E) 1120 kg/m^3

36. A hospital keeps oxygen cylinders in an emergency room. An oxygen cylinder contains gas at a gauge pressure of 220 kPa at a temperature of 27 °C. During transportation in summer, the cylinder temperature rises to 47 °C. What is the new gauge pressure inside the cylinder? Assume the cylinder volume is constant, oxygen behaves as an ideal gas, and atmospheric pressure is 100 kPa.

(A) 234 kPa (B) 241 kPa (C) 331 kPa (D) 334 kPa (E) 341 kPa

37. During a liver ultrasound scan, the transducer operates at frequency f = 5.0 MHz. The sound speed in liver tissue is v = 1540 m/s. The emitted ultrasound pulse contains 3 cycles per pulse (i.e., the spatial pulse length (SPL) corresponds to 3 wavelengths). Assume the minimum separable distance along the beam direction (axial resolution) is Δz_{min} = SPL/2. What is the minimum tumor thickness (along the beam direction) that can be resolved as a distinct structure?

(A) 0.15 mm (B) 0.23 mm (C) 0.46 mm (D) 0.92 mm (E) 1.54 mm

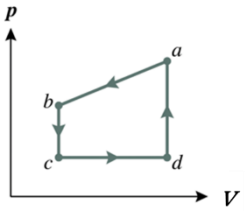
38. The deformation and the restoring force of an elastic string obey Hooke's law. When the string is stretched to twice its original length, the speed of transverse waves on the string is *v*. What is the wave speed on the string when it is stretched to four times its original length? Assume the mass of the string remains constant and is uniformly distributed.
(A) v (B) $\sqrt{2}v$ (C) $\sqrt{3}v$ (D) $2v$ (E) $\sqrt{6}v$

39. A supersonic jet fighter flies horizontally at a constant altitude of 3400 m with a speed of Mach 1.25. Assuming the speed of sound is 340 m/s, how much time will elapse after the jet passes directly over an observer before the shock wave (sonic boom) reaches them?
(A) 4.00 s (B) 6.00 s (C) 7.50 s (D) 8.00 s (E) 10.0 s

40. An ideal monatomic gas expands from volume V_0 to $2V_0$ along a straight line path in the *P*-*V* (pressure-volume) diagram from (P_0, V_0) to ($P_0/2$, $2V_0$). What is the heat *Q* absorbed by the gas in this process?
(A) $0.75P_0V_0$ (B) P_0V_0 (C) $1.25P_0V_0$ (D) $1.5P_0V_0$ (E) $2P_0V_0$

41. A cylindrical rod of length *L* and radius *R* is insulated on its surface. Its thermal conductivity k varies with temperature as $k(T) = \alpha T$. If the two ends of the rod are maintained at T_1 and T_2, the heat current *dQ/dt* is proportional to _____.
(A) $\ln(T_1/T_2)$ (B) $\sqrt{T_1} - \sqrt{T_2}$ (C) $T_1 - T_2$
(D) $T_1^2 - T_2^2$ (E) $T_1^3 - T_2^3$

42. The figure represents a closed cycle for an ideal gas (the figure is not drawn to scale). The change in the internal energy of the gas as it moves from *a* to *c* along the path *abc* is -500 J. As the gas moves from state *c* to state *d*, 400 J of heat is transferred to the system. An additional 200 J of heat is absorbed by the gas as it moves from *d* back to *a*. What is the work done on the gas as it moves from *c* to *d*?



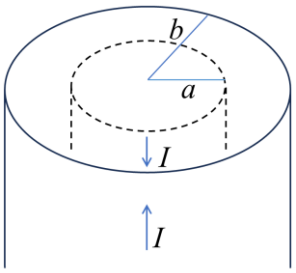
(A) −100 J (B) 100 J (C) −300 J (D) 300 J (E) −700 J

43. A heat engine operates between a high-temperature reservoir at 500 K and a low-temperature reservoir at 300 K. In each cycle, the engine absorbs 1000 J of heat from the high-temperature reservoir and performs 500 J of work. Which of the following statements regarding this engine is **correct**?
(A) It violates the first law of thermodynamics but not the second.
(B) It violates the second law of thermodynamics but not the first.
(C) It violates both the first and second laws of thermodynamics.
(D) It violates neither law and is theoretically possible.
(E) There is insufficient information to determine if any laws are violated.

44. A gas is at 200 K. If we wish to double the root-mean-square speed of the molecules of the gas, to what value must we raise its temperature?

(A) 283 K (B) 400 K (C) 566 K (D) 800 K (E) 1130 K

45. A long coaxial cable consists of a solid inner conductor of radius a carrying current I and a thin outer shell of radius b carrying return current I. The magnetic field at distance r $(a < r < b)$ is _____. (Given: permeability constant μ_0)



(A) 0 (B) $\mu_0 I/(2\pi a)$ (C) $\mu_0 I/(2\pi r)$
(D) $\mu_0 Ir/(2\pi ab)$ (E) $\mu_0 I/(2\pi b)$

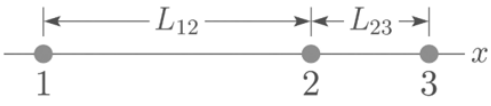
46. A small AC generator is used to power motion sensors on a treadmill. The generator coil rotates in a uniform magnetic field and must produce an emf of 373 V. How many turns of wire are required? (Given: Magnetic field B = 0.60 T, Coil area A = 0.15 m^2, Rotation frequency f = 60.0 Hz)

(A) 8 (B) 11 (C) 14 (D) 17 (E) 20

47. When operating on a 120-V circuit, an electric heater receives 1.30×10^3 W of power, a toaster receives 1.00×10^3 W, and an electric oven receives 1.54×10^3 W. If all three appliances are connected in parallel on a 120-V circuit and turned on, what is the total current drawn from an external source?

(A) 24.0 A (B) 32.0 A (C) 40.0 A
(D) 48.0 A (E) none of the above

48. As shown in the figure, three charged particles (1, 2, and 3) are positioned along an x-axis. Particles 1 and 2 are fixed in place. Particle 3 is free to move, but the net electrostatic force exerted on it by Particles 1 and 2 happens to be zero. Given that the distance between Particles 1 and 2 is L_{12}, the distance between Particles 2 and 3 is L_{23}, and they satisfy the relationship $L_{12} = 2\,L_{23}$. What is the ratio of the charges q_1/q_2?



(A) 4 (B) −4 (C) 9 (D) −9 (E) −8

49. A parallel-plate capacitor has an initial capacitance of $C_0 = 6$ μF. The capacitor is first connected to a 100 V battery until fully charged and then disconnected from the power source. A dielectric slab with a dielectric constant $\kappa = 3$ is then inserted symmetrically between the plates. The thickness of the slab is exactly half of the plate separation distance. What is the external work involved in the process of inserting the dielectric slab?

(A) 10 mJ (B) −10 mJ (C) 15 mJ (D) −15 mJ (E) 0

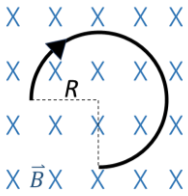
50. In two LRC series AC circuits, suppose circuit 1 has $R_1 = 60\,\Omega$, $C_1 = 300\,\mu F$, $L_1 = 0.80\,H$ and circuit 2 has $R_2 = 120\,\Omega$, $C_2 = 600\,\mu F$, $L_2 = 1.60\,H$. Find the ratio of $\frac{f_1}{f_2}$, where f_1 and f_2 are the resonance frequencies of circuits 1 and 2, respectively.

(A) $\frac{1}{2}$ (B) $\frac{1}{\sqrt{2}}$ (C) 1 (D) $\sqrt{2}$ (E) 2

51. A long solenoid has 5000 turns per meter and a cross-sectional area of 2.0×10^{-4} m^2. A larger secondary coil with 500 turns, which has a cross-sectional area of 5.0×10^{-4} m^2, and a total resistance of $2\pi\ \Omega$ is placed outside and coaxial with the central part of the solenoid. The current in the solenoid drops uniformly from 4.0 A to 0 A in a time interval of $\Delta t = 0.1$ s. What is the magnitude of the induced current in the external coil during this time interval? (Given: permeability constant $\mu_0 = 4\pi \times10^{-7}$ T·m/A)

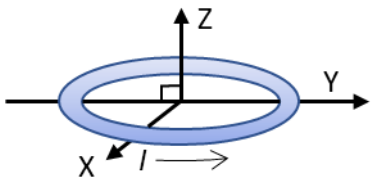
(A) 4.0 mA (B) 5.0 mA (C) 6.0 mA (D) 7.0 mA (E) 8.0 mA

52. A wire is bent into a three-quarter circular loop of radius R and carries a steady current I. It is placed in a uniform magnetic field $\vec{B}$ perpendicular to the plane of the three-quarter circular loop. The magnitude of net magnetic force on the wire is _____.



(A) 0 (B) πRIB (C) $2RIB$ (D) $(3/4)\pi RIB$ (E) $\sqrt{2}RIB$

53. A circular coil 0.05 m in radius, with 50 turns of wire, lies on a horizontal plane. It carries a counterclockwise current of 8.0 A. The coil is in a uniform 1.50 T magnetic field directed toward the +Y − direction. Find the torque on the coil. (Given: Unit victors $\hat{\imath}$, $\hat{\jmath}$ and $\hat{k}$ point in the directions of the positive X−, Y− and Z− axes and have magnitude of 1)



(A) $-0.03\,\pi\,\hat{\imath}$ (B) $-1.50\,\pi\,\hat{\imath}$ (C) $0.03\,\pi\,\hat{k}$ (D) $1.5\,\pi\,\hat{k}$ (E) $0.03\,\pi\,\hat{\jmath}$

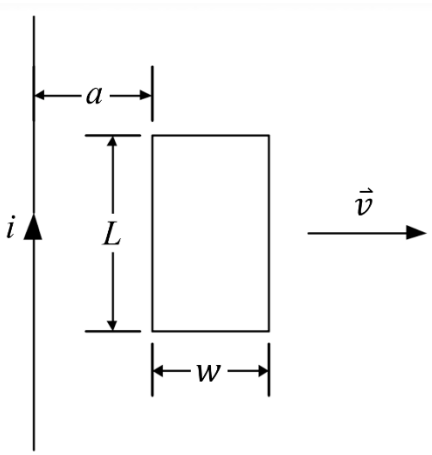
54. A beam of monochromatic light with a wavelength of λ = 600 nm is incident perpendicularly onto a diffraction grating with 500 lines/mm. What is the maximum diffraction order (m) that can be observed on the screen? (Note: Consider only the orders on one side of the central maximum, excluding $m = 0$)

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

55. Alice directs a beam of 0.12 nm x rays at certain planes of a silicon crystal. As she increases the angle of incidence of the beam from zero, the first strong interference maximum occurs when the beam makes an angle of $\theta = \tan^{-1}(\frac{3}{4})$ with the planes. How far apart are the planes?

(A) 0.045 nm (B) 0.075 nm (C) 0.1 nm (D) 0.15 nm (E) 0.2 nm

56. A rectangular conducting loop with resistance R lies in the same plane as a long straight wire carrying a steady current i. The nearest edge of the loop is initially at a distance a from the wire, and the loop has the width w and length L as shown in the figure. The loop is then pulled directly away from the wire with constant speed v. As the motion just begins, the induced current in the loop is _____. (Given: permeability constant μ_0)



(A) $\frac{\mu_0 ivwL}{2\pi R}\cdot\frac{1}{a^2}$ (B) $\frac{\mu_0 ivwL}{2\pi R}\cdot\frac{1}{aw}$ (C) $\frac{\mu_0 ivwL}{2\pi R}\cdot\frac{1}{(a+w)^2}$

(D) $\frac{\mu_0 ivwL}{2\pi R}\cdot\frac{1}{a(a+w)}$ (E) $\frac{\mu_0 ivwL}{2\pi R}\cdot\frac{1}{w(a+w)}$

57. A thin layer of oil with an index of refraction n = 1.5 coats a glass plate with an index of refraction of 1.8. White light from air (n = 1.0) is incident normal to the film. In the reflected light: (1) Fully constructive interference occurs at a wavelength of λ_1 = 600 nm. (2) Fully destructive interference occurs at a wavelength of λ_2 = 400 nm. Assume that both wavelengths correspond to the same interference order, what is the thickness of the oil film?

(A) 100 nm (B) 133 nm (C) 167 nm (D) 200 nm (E) 266 nm

58. What is the de Broglie wavelength of an electron accelerated from rest through a potential difference of 50.0 V?

(A) 0.100 nm (B) 0.139 nm (C) 0.174 nm

(D) 0.834 nm (E) none of the above

59. The radioactive tracer has a half-life of $T_{1/2} = 2.0\times10^3$ years. A sample initially contains $N_0 = 8.0\times10^{15}$ nuclei. What is the activity of the remaining nuclei after 4.0×10^3 years? (Given: 1 year = 3.15×10^7 s, 1 Ci = 3.7×10^{10} decays/s, ln2 = 0.693)

(A) 3.0×10^{-7} Ci (B) 5.9×10^{-7} Ci (C) 1.4×10^{-5} Ci

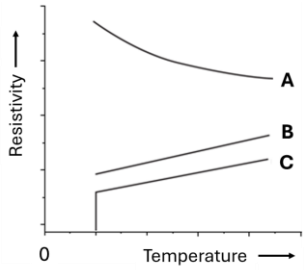
(D) 5.9×10^{-5} Ci (E) 2.2×10^{-3} Ci

60. In the Bohr model of the hydrogen atom, the reference level of zero energy is taken to be that of a free electron at infinite separation from the nucleus. Let K denote the kinetic energy of the electron in a bound orbit and let E be its total mechanical energy. Which of the following correctly describes the relationship between K and E?

(A) $K = -E$ (B) $K = E$ (C) $K = E/2$

(D) $K = -E/2$ (E) $K = -2E$

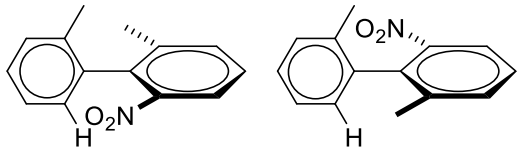
61. Temperature dependence of resistivity for three materials (**A**, **B** and **C**) is depicted below. Which of the following statements is (are) **correct**?



I. **A** represents an insulator. II. **B** is a metal. III. **C** represents a superconductor.

(A) I and II (B) II and III (C) I and III (D) II (E) III

62. Which of the following terms best describes the pair of compounds shown below?



(A) same compound (B) constitution isomers (C) enantiomers

(D) diastereomers (E) conformers

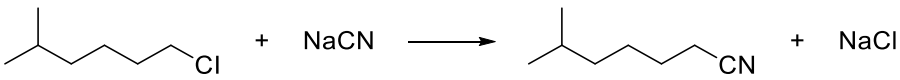
63. Rank the following in terms of nucleophilic strength:

I. CH_3S^- II. CH_3SH III. H_2S IV. HS^- V. $CH_3SH_2^+$

(A) I>II>III>IV>V (B) V>IV>III>II>I (C) I>IV>II>III>V

(D) V>I>IV>II>III (E) I>II>IV>V>III

64. Consider the S_N2 reaction of 1-chloro-5-methylhexane with CN^- ion.



Assuming no other changes, what effect on the rate would result from simultaneously doubling the concentrations of both 1-chloro-5-methylhexane and NaCN?

(A) No effect (B) It would double the rate.

(C) It would triple the rate. (D) It would increase the rate four times.

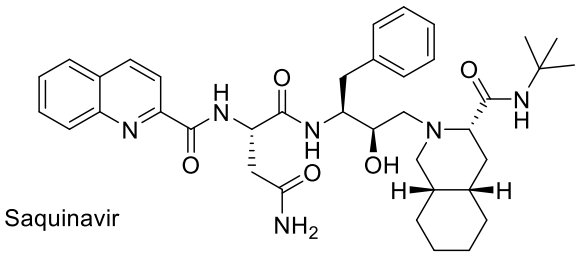
(E) It would increase the rate six times.

65. A solution contains the ions Ag^+, Pb^{2+}, and Ni^{2+}. Dilute solutions of NaCl, Na_2SO_4, and Na_2S are available to separate the positive ions from each other. In order to effect separation, the solutions should be added in which order?

(A) Na_2SO_4, NaCl, Na_2S (B) Na_2SO_4, Na_2S, NaCl (C) Na_2S, NaCl, Na_2SO_4

(D) NaCl, Na_2S, Na_2SO_4 (E) NaCl, Na_2SO_4, Na_2S

66. Which of the following functional groups is **absent** in the HIV protease inhibitor Saquinavir?



(A) alcohol (B) amide (C) aromatic (D) amine (E) ketone

67. In the unit cell of face-center cubic, the ratio of tetrahedral holes to atoms (or ions) is _____.

(A) 1:1 (B) 1:2 (C) 2:1 (D) 1:4 (E) 4:1

68. Which will be the major product when *N*,*N*-dimethylpropanamide is treated with $LiAlH_4$?

(A) $CH_3CH_2CONH_2$ (B) $CH_3CH_2CH_2NH_2$ (C) $CH_3CH_2CH_2OH$
(D) $CH_3CH_2CH_2N(CH_3)_2$ (E) $CH_3CH_2N(CH_3)_2$

69. According to the concept of hard and soft acids and bases (HSABs), arrange the solubilities of silver halides in water (25 °C).

(A) $AgF_{(s)} > AgCl_{(s)} > AgBr_{(s)} > AgI_{(s)}$ (B) $AgI_{(s)} > AgBr_{(s)} > AgCl_{(s)} > AgF_{(s)}$
(C) $AgF_{(s)} > AgI_{(s)} > AgBr_{(s)} > AgCl_{(s)}$ (D) $AgI_{(s)} > AgCl_{(s)} > AgBr_{(s)} > AgF_{(s)}$
(E) none of the above

70. Three types of chemical reactions are described below. Which of the following statements is **correct**?

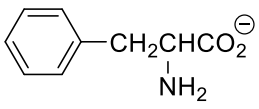
I. $CH_3COOH_{(l)} + CH_3CH_2OH_{(l)} \xrightarrow{H^+} CH_3COOCH_2CH_{3(l)} + H_2O$

II. $AgNO_{3(aq)} + KCl_{(aq)} \longrightarrow AgCl_{(s)} + K^+_{(aq)} + NO_3^-{}_{(aq)}$

III. $Cu_{(s)} + 2Fe^{3+}_{(aq)} \longrightarrow Cu^{2+}_{(aq)} + 2Fe^{2+}_{(aq)}$

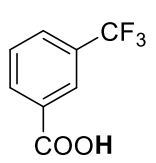
(A) At 25 °C (1 atm), the reaction rate for type I is the fastest.
(B) This equation of type II is called the net ionic equation.
(C) Type III is a precipitation reaction.
(D) The reduced half-reaction of type III is $Cu_{(s)} \rightarrow Cu^{2+} + 2e^-$.
(E) Type I involves bond cleavage and formation reaction.

71. Under what condition would phenylalanine exist as in the following structure?

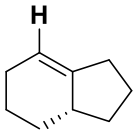


(A) at a low pH (B) at a high pH (C) at the pI
(D) when pH = pKa (E) none of the above

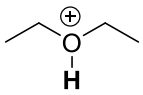
72. Rank the **bold** hydrogens for the following compounds from most acidic to least acidic.



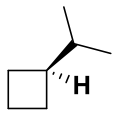
I



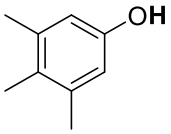
II



III



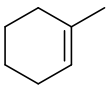
IV



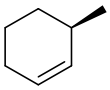
V

(A) I > II > III > IV > V (B) III > V > II > I > IV (C) V > II > IV > III > I
(D) III > I > V > II > IV (E) V > III > I > II > IV

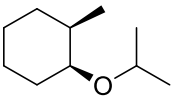
73. Which will be the major product when *trans*-1-bromo-2-methylcyclohexane reacts with sodium isopropoxide in isopropanol?



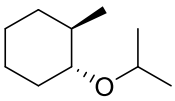
I



II



III



IV

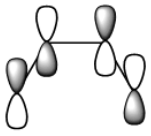
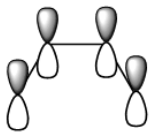
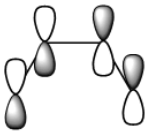
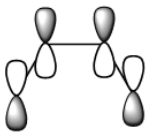
(A) I (B) II (C) III and IV (D) III (E) IV

74. Which conformation of *trans*-1-isopropyl-3-methylcyclohexane would be present in greatest amount at equilibrium?
(A) The conformation with the methyl group equatorial and the isopropyl group axial.
(B) The conformation with the methyl group axial and the isopropyl group equatorial.
(C) The conformation with both groups axial.
(D) The conformation with both groups equatorial.
(E) The twist boat conformation.

75. Which of the following reagents can be used to convert cyclopentanol to cyclopentane?
(A) TsCl, pyridine followed by $LiAlH_4$ (B) $Na_2Cr_2O_7$, H_2SO_4
(C) $NaBH_4$ followed by H_3O^+ (D) H_2SO_4, heat followed by H_2, Pt-catalyst
(E) both A and D

76. When two carbenes collide, they immediately dimerize to give?
(A) an alkane (B) an alkene (C) an alkyne
(D) an aromatic ring (E) a carbanion

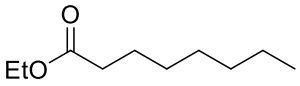
77. Each of the diagram shown below represents the atomic orbitals that described the π electron system in butadiene: shade areas are positive; unshaded areas are negative. Which of these diagrams would be expected to represent the highest energy molecular orbital?

(A)  (B)  (C)  (D)  (E) none of the above

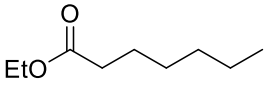
78. Calculate the total number of unpaired electrons in the following complex ions: $Zn(H_2O)_6^{2+}$, $Ni(CN)_4^{2-}$ (square planar), $Co(NH_3)_6^{3+}$ (strong field).

(A) 0 (B) 1 (C) 2 (D) 3 (E) 4

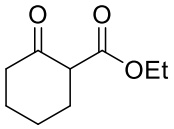
79. Which will be the major product when diethyl heptanedioate reacts with sodium ethoxide?



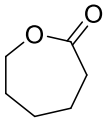
I



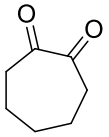
II



III



IV



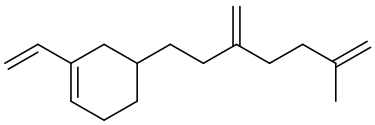
V

(A) I (B) II (C) III (D) IV (E) V

80. What is the symmetry of BF_3?

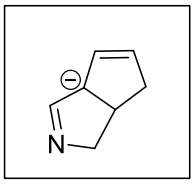
(A) C_3 (B) C_{3v} (C) C_6 (D) D_{3h} (E) D_6

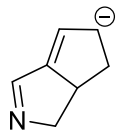
81. How many moles of carbon dioxide are generated when one mole of the compound shown below is treated with warm, concentrated $KMnO_4$?



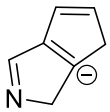
(A) 1 (B) 2 (C) 3 (D) 4 (E) 8

82. Which of the following species is/are a resonance form(s) of the species in the box?

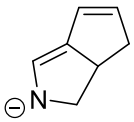




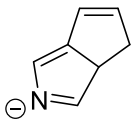
I



II



III



IV

(A) I and II (B) I and III (C) II and III (D) I and IV (E) II and IV

83. How many enantiomer(s) can be drawn from $CH_3CHClCHBrCH_3$?

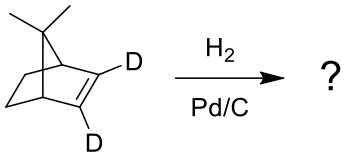
(A) 1 (B) 2 (C) 3 (D) 4 (E) 6

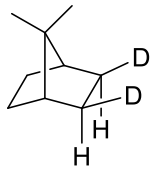
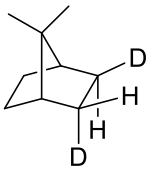
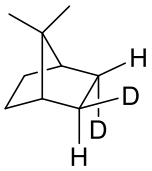
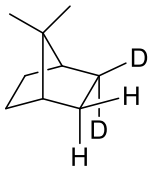
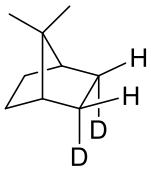
84. Consider the following equilibrium reaction : $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} + 92.94$ kJ. Which of the following changes will shift the balance to the right?

I. increase temperature II. decrease temperature III. increase volume
IV. decrease volume V. remove some NH_3 VI. add some NH_3
VII. remove some N_2 VIII. add some N_2

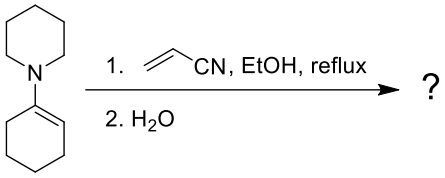
(A) I, IV, VI, VII (B) II, III, V, VIII (C) II, IV, V, VIII
(D) I, VI, VIII (E) I, III, V

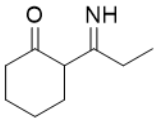
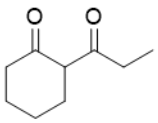
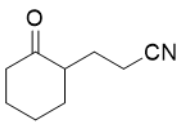
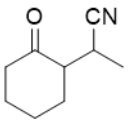
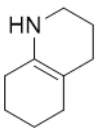
85. Which will be the major product of the following reaction?



(A)  (B)  (C)  (D)  (E) 

86. Which will be the major product of the following reaction?



(A)  (B)  (C)  (D)  (E) 

87. How many unpaired electrons are found in complex $[Mn(H_2O)_6]^{2+}$ with a high-spin electron configuration?

(A) 0 (B) 1 (C) 3 (D) 5 (E) none of the above

88. Which of the following species obeys the 18-electron rule?

(A) $(\eta^5\text{-}C_5H_5)_2Fe$ (B) $(\eta^5\text{-}C_5H_5)_2Co$ (C) $(\eta^5\text{-}C_5H_5)_2Ni$
(D) $[(\eta^5\text{-}C_5H_5)_2Ni]^+$ (E) $[(\eta^5\text{-}C_5H_5)_2Fe]^+$

89. Calculate $\Delta H°$ for the reaction $C_4H_{4(g)} + 2H_{2(g)} \rightarrow C_4H_{8(g)}$, using the following data:
$\Delta H°_{combustion}$ for $C_4H_{4(g)} = -2341$ kJ/mol
$\Delta H°_{combustion}$ for $H_{2(g)} = -286$ kJ/mol
$\Delta H°_{combustion}$ for $C_4H_{8(g)} = -2755$ kJ/mol

(A) –128 kJ (B) –158 kJ (C) 128 kJ (D) 158 kJ (E) 300 kJ

90. When an iron knife is dipped in an aqueous solution of copper sulphate, a layer of reddish-brown precipitate is formed. Which compound or element is the layer of reddish-brown precipitate?

(A) iron sulphate (B) copper (C) rust
(D) copper sulphate (E) iron