112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. Which unit is ***not*** the SI (international system of units) derived unit?
   (A) dyne (B) watt (C) newton (D) volt (E) tesla

2. Suppose a block is placed on a rough surface inclined relative to the horizontal and the coefficient of static friction between the block and the rough surface is μ_S. Let the incline angle be increased from $\theta = 0$ until the block starts to move. What is the critical angle θ_c at which this slipping just occurs?
   (A) $\theta_c = \arctan(\mu_S)$ (B) $\theta_c = \arccos(\mu_S)$ (C) $\theta_c = \arcsin(\mu_S)$
   (D) $\theta_c = \pi/2$ (E) None of the above.

3. An escalator is used to move 20 people (60 kg each) per minute from the first floor of a department store to the second floor, 5 m above. The power required is approximately _____.
   (A) 100 W (B) 200 W (C) 1000 W (D) 2000 W (E) 4000 W

4. An air-bag company is designing a new product. The specification requires passengers of mass 75 kg to sit in a car traveling at 60 km/h. When the car hits the wall and stops there, the air-bag extends the stopping time up to 0.4 s. What is the average force on the passenger during this collision?
   (A) 408 N (B) 1680 N (C) 3125 N (D) 11259 N (E) 30625 N

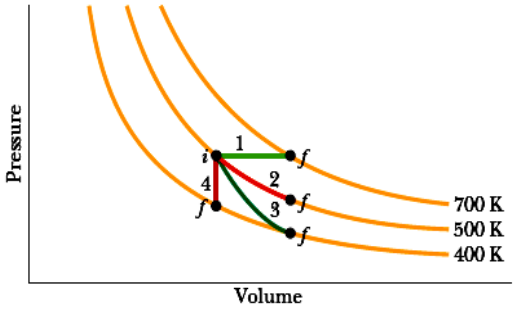
5. The electric inductance *L* is defined as the magnetic flux Φ_B divided by current *I*. What is the unit of the inductance *L* divided by electric resistance *R* ?
   (A) tesla (B) Hz (C) Wb
   (D) sec (E) None of the above.

6. A hydraulic press has one piston of diameter 2 cm and the other piston of diameter 8 cm. What force must be applied to the smaller piston to obtain a force of 1600 N at the larger piston?
   (A) 6 N (B) 25 N (C) 100 N (D) 400 N (E) 1600 N

7. The position of a particle is given by the expression $x = 4\cos(3\pi t + \pi)$, where *x* is in meters and *t* is in seconds. What is the frequency?
   (A) 1.0 Hz (B) 1.5 Hz (C) 3.0 Hz (D) 4.0 Hz (E) 9.4 Hz

8. The average molecular translational kinetic energy of a gas molecule is _____.
(The ideal gas constant is R. Boltzmann constant is k_B. Temperature of gas is T.)
(A) $(3/2)k_BT$ (B) $(3/2)RT$ (C) $(1/2)k_BT$ (D) $(1/2)RT$
(E) $(n+3)k_BT/2$, where n is the number of internal degrees of freedom.

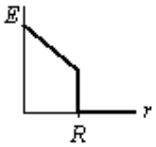
9. A gas in a cylinder starts from initial state i to finial state f through 4 different paths as shown in the figure. Regarding to the heat energy, work, and internal energy, which statements is ***incorrect***?

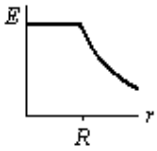


(A) Path 1 is isobaric expansion, gas must be heated.
(B) Path 2 is isothermal expansion; no work is involved in this process.
(C) Path 3 is adiabatic expansion, therefore no heat transfer occurred.
(D) Path 4 is isochoric cooling; heat is extracted out of gas.
(E) Gas do not do work for path 4 only.

10. A resistor of unknown resistance and a 15 Ω resistor are connected across a 20 V *emf* in such a way that a 2 A current is observed. What is the value of the unknown resistance?
(A) 5 Ω (B) 7.5 Ω (C) 12 Ω (D) 30 Ω (E) 75 Ω

11. A conducting sphere of radius R contains a positive charge. Which figure correctly represents the magnitude of the electric field E as a function of the distance r from the center of the sphere?

(A) 

(B) 

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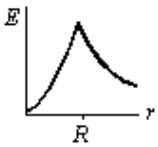
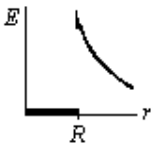
(D) 

(E) 

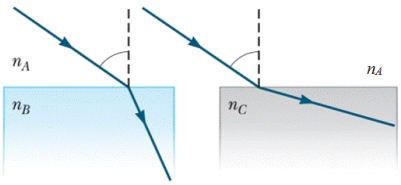
12. Which equation is ***not*** one of Maxwell's equations?
(A) $\oint \vec{E} \cdot d\vec{A} = \dfrac{Q_{encl}}{\varepsilon_0}$ (B) $\vec{\nabla} \cdot \vec{B} = 0$
(C) $\oint \vec{B} \cdot d\vec{l} = \mu_0 \left(i_C + \varepsilon_0 \dfrac{d\Phi_E}{dt} \right)_{encl}$ (D) $\vec{\nabla} \times \vec{E} = -\dfrac{\partial \vec{B}}{\partial t}$
(E) $\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$

13. The flux of the electric field $(24)\hat{\imath} + (30)\hat{\jmath} + (-16)\hat{k}$ N/C through a 2 m^2 portion of the xz plane is _____.
(A) 16 N·m^2/C (B) −48 N·m^2/C (C) 48 N·m^2/C
(D) −60 N·m^2/C (E) 60 N·m^2/C

14. An object is 12 cm in front of a concave spherical mirror, and the image is 3 cm in front of the mirror. What is the focal length of the mirror?

(A) 0.25 cm (B) 1.5 cm (C) 2.4 cm (D) 4 cm (E) 13 cm

15. A light from medium A with refractive index (n_A) enters medium B and medium C with refractive index, n_B and n_C respectively. Which of the followings is correct?



(A) $n_A > n_B > n_C$ (B) $n_A > n_C > n_B$ (C) $n_B > n_C > n_A$
(D) $n_B > n_A > n_C$ (E) $n_C > n_A > n_B$

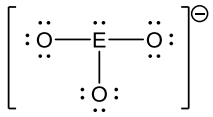
16. Complete the following nuclear reaction:

$$^{238}_{92}\mathrm{U} + {}^{12}_{6}\square \longrightarrow {}^{A}_{B}\mathrm{Cf} + 6\,{}^{1}_{0}\mathrm{n}$$

The $\square$, A and B should be:

(A) He, 249 and 86 (B) C, 244 and 98 (C) C, 249 and 92
(D) C, 249 and 98 (E) He, 244 and 98

17. An anion has the following Lewis structure:



What is the possible identity for element E?

(A) Si (B) P (C) S (D) Ar (E) Cl

18. Determine Lewis base strength in the gas phase of following amines:

(A) $NMe_3 > NH_2Me > NH_3$ (B) $NH_2Me > NMe_3 > NH_3$ (C) $NH_3 > NMe_3 > NH_2Me$
(D) $NH_3 > NH_2Me > NMe_3$ (E) None of the above.

19. Using the data below, calculate the normal boiling point of liquid **A** at 1 atm,
A(*liquid*) → **A**(*gas*): the $\Delta H° = 25.0$ kJ/mol and the $\Delta S° = 50.0$ $JK^{-1}mol^{-1}$

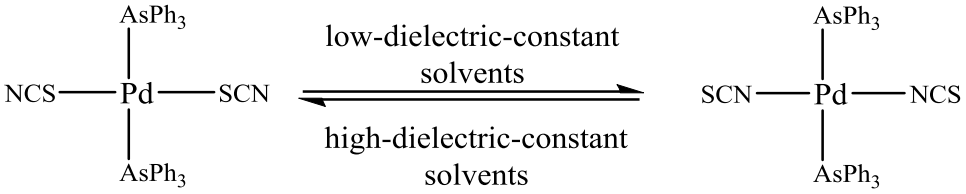
(A) 50 K (B) 200 K (C) 227 K (D) 323 K (E) 500 K

20. Which of the followings octahedral complexes will ***not*** form precipitate of AgI at once after the aqueous $AgNO_3$ is added?

(A) $Co(NH_3)_6I_3$ (B) $Pt(NH_3)_4I_4$ (C) Na_2PtI_6
(D) $Cr(NH_3)_4I_3$ (E) All of them will form AgI precipitate.

21. How to make a p-type semiconductor?
(A) Dope host atoms (Si) with atoms having fewer valence electrons than the host, such as B.
(B) Dope host atoms (As) with atoms having fewer valence electrons than the host, such as Se.
(C) Dope host atoms (Si) with atoms having more valence electrons than the host, such as As.
(D) Dope host atoms (As) with atoms having more valence electrons than the host, such as Ge.
(E) None of the above.

22. Based on reaction shown as below, the two complexes can be classified into which type of isomerism?



(A) stereoisomerism (B) optical isomerism (C) geometric isomerism
(D) ionization isomerism (E) linkage isomerism

23. What is the product called after glycine and alanine undergo condensation reactions?
(A) ester (B) dipeptide (C) DNA
(D) polysaccharides (E) None of the above.

24. Which compound does ***not*** possess a sp^2 hybridized orbital?
(A) 2-butanone (B) aspirin (C) acetic anhydride
(D) 2-propanol (E) aniline

25. Consider the following orderings. Which of these gives a correct trend in ionization energy?
I Be < Mg < Ca < Sr
II Cl < Si < P < Al
III F < Cl < Br < I
IV $Na^+ < Mg^{2+} < Al^{3+} < Si^{4+}$
(A) I (B) II (C) III (D) IV (E) None of the above.

26. What is the ***correct*** order of the following bonds in terms of increasing polarity?
(A) N-Cl, P-Cl, As-Cl (B) P-Cl, N-Cl, As-Cl (C) As-Cl, N-Cl, P-Cl
(D) P-Cl, As-Cl, N-Cl (E) As-Cl, P-Cl, N-Cl

27. Which of the following electron configurations is ***incorrect***?
(A) S^{2-}: $1s^2 2s^2 2p^6 3s^2 3p^6$ (B) Na^+: $1s^2 2s^2 2p^6$
(C) Ga: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$ (D) V: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^3$
(E) I: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$

28. How many moles of $Ca(NO_3)_2$ must be added to 0.5 L of a 0.4 *M* KF solution to begin precipitation of CaF_2? For CaF_2, $K_{sp} = 4.0 \times 10^{-11}$.
(A) 2.0×10^{-12} (B) 1.0×10^{-10} (C) 2.0×10^{-10} (D) 1.0×10^{-9} (E) 5.0×10^{-9}

29. For the reaction below,

$$PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)} \quad \Delta G^{o} = -92.5 \text{ kJ, at } 298K$$

Which of the following statements is ***true***?
(A) This reaction is endothermic.
(B) ΔG for this reaction has to be negative at all temperatures.
(C) K_p is smaller than 1.00 when ΔG for the reaction is negative.
(D) $\Delta S°$ for this reaction is negative.
(E) All of the above statements are true.

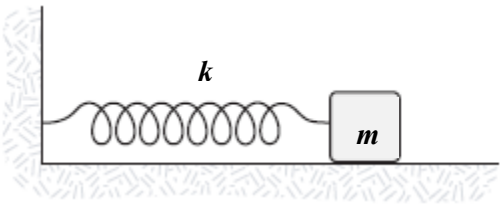
30. Which of the following species needs resonance to adequately describe its structure?
(A) H_2O (B) CO_3^{2-} (C) NH_3 (D) HCN (E) NH_4^+

【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. An object of mass *m* is sliding with speed *v* at some instant across a level tabletop, with which its coefficient of kinetic friction is μ. It then moves through a distance *d* and comes to rest. Which of the following equations for the speed *v* is reasonable? (Gravitational acceleration is *g*)
(A) $(2\mu gd)^{1/2}$ (B) $(mgd)^{1/2}$ (C) $(2\mu mgd)^{1/2}$ (D) $(2\mu gd)^{-1/2}$ (E) $(2\mu d)^{1/2}$

32. A force acting on an object moving along the *x* axis is given by $Fx = (14x - 3x^2)$ N, where *x* is in m. How much work is done by this force as the object moves from $x = -1$ m to $x = +2$ m?
(A) +12 J (B) +28 J (C) +40 J (D) +42 J (E) −28 J

33. The block shown in the figure is released from rest when the spring is stretched a distance *d*. If $k = 75$ N/m, $m = 0.5$ kg, $d = 10$ cm, and the coefficient of kinetic friction between the block and the horizontal surface is equal to 0.25, what is the speed of the block when it first passes through the position for which the spring is unstretched. (Gravitational acceleration $g = 10$ m/s^2)

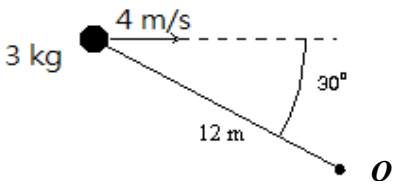


(A) 0.53 m/s (B) 0.92 m/s (C) 1.00 m/s (D) 1.22 m/s (E) 1.44 m/s

34. A police crime lab is trying to determine whether someone was murdered or died as a result of an accident. The victim was struck in the temple by a 4 kg sculpture that is alleged to have fallen off a bookcase. The sculpture presumably fell a distance of 20 m and the corner that struck him had an area of 0.25 cm^2. If the time for the sculpture to stop was 1 ms, the pressure on his temple, in N/m^2, was _____. (Gravitational acceleration g = 10 m/s^2)

(A) 3.2×10^5 (B) 1.6×10^6 (C) 3.2×10^6 (D) 1.6×10^9 (E) 3.2×10^9

35. A 3 kg particle moves to the right at 4 m/s as shown in the figure. The magnitude of its angular momentum in (kg · m^2/s) about the point *O* is _____.



(A) 0 (B) 48 (C) 72 (D) 144 (E) 1728

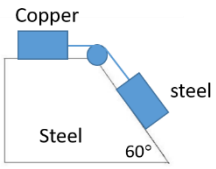
36. A particle moves in the *xy* plane, starting from the origin at t = 0 with an initial velocity having an x component of 20 m/s and a y component of −15 m/s. The particle experiences an acceleration in the x direction, given by a_x = 4 m/s^2. What is the total velocity at any time?

(A) $(4t)\hat{\imath} + (-15t)\hat{\jmath}$ (B) $(24t)\hat{\imath} + (-15t)\hat{\jmath}$ (C) $(20 + 4t)\hat{\imath} + (-15)\hat{\jmath}$
(D) $(20)\hat{\imath} + (-15)\hat{\jmath}$ (E) $(24)\hat{\imath} + (-15t)\hat{\jmath}$

37. A grindstone increases in an angular speed from 4 rad/s to 12 rad/s in 4 s. Through what angle does it turn during that time interval if the angular acceleration is constant?

(A) 8 rad (B) 12 rad (C) 16 rad (D) 32 rad (E) 64 rad

38. A 1 kg copper block and a 6 kg steel block are connected by a light string over a frictionless pulley. The two blocks are allowed to move on a fixed steel block wedge (θ = 60°) as shown in the figure. If the coefficients of friction of the copper-steel and steel-steel are 0.4 and 0.6, respectively, what is the acceleration of the two blocks? (Gravitational acceleration g = 10 m/s^2)

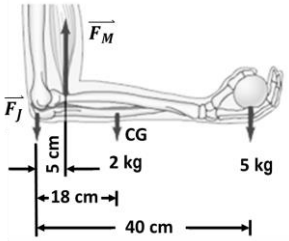


(A) 5.28 m/s^2 (B) 5.08 m/s^2 (C) 4.88 m/s^2
(D) 4.68 m/s^2 (E) 4.28 m/s^2

39. A car travels at a constant speed of 60 km/hr on a level circular turn of radius of 40 m. What is the minimum coefficient of static friction between tire and the roadway to allow the car to make the turn without sliding? (Gravitational acceleration g = 10 m/s^2)

(A) 0.83 (B) 0.73 (C) 0.63 (D) 0.53 (E) 0.43

40. A 5 kg ball is held in the hand as shown in the figure, with the arm horizontal and 40 cm from the elbow joint. The forearm mass is 2 kg and the center of gravity is 18 cm from the joint. The biceps connect to the arm at 5 cm from the joint. How much force (F_M) must the biceps exert to hold the ball in place? (Gravitational acceleration g = 10 m/s^2)

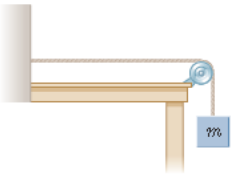


(A) 472 N (B) 236 N (C) 118 N (D) 59 N (E) 30 N

41. If middle C (262 Hz) and C$^{\#}$ (277 Hz) are played together, it would cause interference beats. What the beat frequency would be if each is played one octave lower (each frequency reduced by a factor of 2)?

(A) 30 Hz (B) 15 Hz (C) 7.5 Hz
(D) 3.75 Hz (E) None of the above.

42. Tension is maintained in a string as in the figure. The observed wave speed is v = 24 m/s when the suspended mass is m = 3 kg. What is the wave speed when the suspended mass is m = 1 kg? (Gravitational acceleration g = 10 m/s^2)



(A) 4.6 m/s (B) 5.7 m/s (C) 8.0 m/s (D) 11.3 m/s (E) 13.9 m/s

43. When an ambulance passes in front of an observer, the sound frequency is 440 Hz when the ambulance is approaching, and the frequency drops to 400 Hz when the ambulance is moving away. What is the speed of the ambulance? (Assume the speed of sound is 345 m/s at that time.)

(A) 13.8 m/s (B) 14.0 m/s (C) 14.4 m/s
(D) 15.4 m/s (E) 16.4 m/s

44. Under ambient conditions, which gas has the adiabatic ratio of molar heat capacities γ most close to 1.4? ($\gamma = C_P/C_V$)

(A) Ar (B) CO (C) Cl_2 (D) CO_2 (E) CH_4

45. A 50 m bridge is made with segments of concrete. If the linear expansion coefficient is 1.2 × 10^{-5} °C^{-1}, how much spacing is needed to allow for expansion during an extreme temperature change of 150 °F?

(A) 2.0 cm (B) 2.5 cm (C) 3.0 cm (D) 3.5 cm (E) 4.0 cm

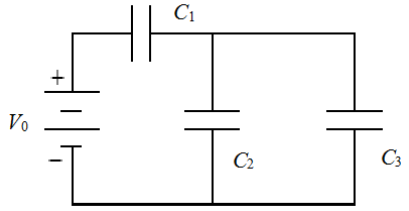
46. A Carnot engine is operating at its theoretical maximum efficiency of 60%. If the waste heat has a temperature of 38 °C, what is the temperature of the boiler?

(A) 94 °C (B) 225 °C (C) 350 °C (D) 504 °C (E) 775 °C

47. A tuning fork is known to vibrate with frequency 262 Hz. When it is sounded along with a mandolin string, four beats are heard every second. Next, a bit of tape is put onto each tine of the tuning fork, and the tuning fork now produces five beats per second with the same mandolin string. What is the frequency of the string?

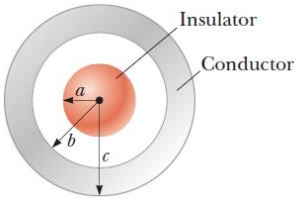
(A) 257 Hz (B) 258 Hz (C) 262 Hz (D) 266 Hz (E) 268 Hz

48. Determine the energy stored in C_2 when C_1 = 15 μF, C_2 = 10 μF, C_3 = 20 μF, and V_0 = 18 V.



(A) 1.60 mJ (B) 0.72 mJ (C) 0.50 mJ (D) 0.32 mJ (E) 0.18 mJ

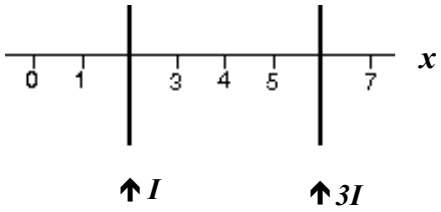
49. A solid, insulating sphere of radius a has a uniform charge density throughout its volume and a total charge Q. Concentric with this sphere is an uncharged, conducting, hollow sphere whose inner and outer radii are b and c as shown in the figure. Find the magnitude of the electric field for $r < a$.



(A) $\mathrm{E} = \frac{1}{4\pi\varepsilon_0}\frac{Qr}{a^3}$ (B) $\mathrm{E} = \frac{1}{4\pi\varepsilon_0}\frac{Qr}{a^2}$ (C) $\mathrm{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$

(D) $\mathrm{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$ (E) $\mathrm{E} = 0$

50. Two long straight current-carrying parallel wires cross the x axis and carry currents I and $3I$ in the same direction, as shown in the figure. At what value of x is the net magnetic field zero?



(A) 1 (B) 3 (C) 4 (D) 5 (E) 7

51. A certain capacitor has a capacitance of 5 μF. After it is charged to 5 μC and isolated, the plates are brought closer together so its capacitance becomes 10 μF. The work done by the agent is about _____.

(A) -1.25×10^{-6} J (B) 8.3×10^{-7} J (C) -8.3×10^{-7} J
(D) 1.25×10^{-6} J (E) -3.75×10^{-6} J

52. A plane with a wing length of 50 m is flying westward where the downward component of the earth's magnetic field is 6×10^{-5} T. What is the difference in potential between the wingtips when the speed of the plane is 720 km/hr, and which wingtip is positive?

(A) 2.16 V, south (B) 2.16 V, north (C) 0.96 V, south
(D) 0.96 V, north (E) 0.60 V, south

53. Implanted medical devices are often charged by transcutaneous energy transfer (TET), which uses a pair of coils in close proximity for wireless charging. The change of current in the coil outside the body causes the magnetic flux of the coil inside the body to change, thus generating an induced electromotive force. There are 10 coils with a radius of 1 cm, and the current of the outer coil drops from 10 A to 0, within 6×10^{-6} s, what is the average induced electromotive force of the inner coil? (Magnetic constant μ_0 is $4\pi \times 10^{-7}$ T·m/A.)
(A) 2.58 V (B) 2.79 V (C) 3.05 V (D) 3.29 V (E) 3.54 V

54. A beam of unpolarized light of intensity I_0 passes through four successive ideal polarizing filters, each of whose polarizing axis makes a 30° angle with the previous one. What is the intensity of the transmitted beam?
(A) 1 (B) 81/256 (C) 27/128 (D) 9/16 (E) 0

55. When sitting in an airplane at an altitude of 10 km, you look down on the ground. Assuming that your pupil is about 1.5 mm in radius and considering the effect of diffraction only, what is the minimum separation s between objects on the ground that you can distinguish? (The wavelength of visible light is around 500 nm.)
(A) 0.5 m (B) 2 m (C) 8 m (D) 20 m (E) 50 m

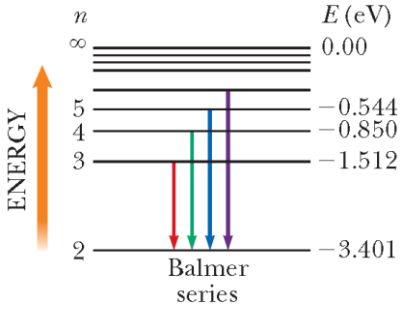
56. A spaceship S_1 is moving away from us at a speed of 0.8 c. Another spaceship S_2 is moving away from us in the opposite direction at a speed of 0.5 c. What is the speed of S_1 measured by an observer on S_2?
(A) 1.3 c (B) 1.0 c (C) 0.97 c (D) 0.93 c (E) 0.89 c

57. Silicon (Si) is a semiconductor material whose properties fit perfectly in solar cells to convert the light energy into electrical energy. Based on this evidence, what the value of energy gap of Si probably is?
(A) several tenths of eV (B) 1.1 eV (C) 3.1 eV
(D) 5.1 eV (E) 7.1 eV

58. The wave function $\psi(x)$ of a particle confined to $0 \le x \le L$ is given by $\psi(x) = Ax$. $\psi(x) = 0$ for $x < 0$ and $x > L$. When the wave function is normalized, the probability density at coordinate x has the value _____.
(A) $2x/L^2$ (B) $2x^2/L^2$ (C) $2x^2/L^3$ (D) $3x^2/L^3$ (E) $2x^3/L^3$

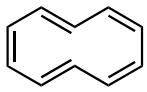
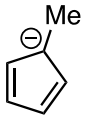
59. A light of wavelength 400 nm falls on a metal surface having a work function 1.70 eV. What is the maximum kinetic energy of the photoelectrons emitted from the metal?
($c = 3.00 \times 10^8$ m/s, $h = 6.626 \times 10^{-34}$ J·s , 1 eV = 1.60×10^{-19} J)
(A) 4.52 eV (B) 3.11 eV (C) 2.82 eV (D) 1.70 eV (E) 1.41 eV

60. The Balmer series for the hydrogen atom corresponds to electronic transitions that terminate in the state with quantum number $n = 2$ as shown in the figure. Consider the photon of the longest wavelength corresponding to a transition shown. What is its wavelength?

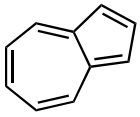
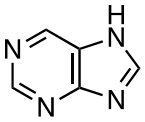


(A) 420 nm (B) 458 nm (C) 540 nm (D) 656 nm (E) 720 nm

61. Which structure is ***not*** considered to have aromaticity?

(A)  (B) 

(C)

(D)  (E) 

62. Solid KF has a lattice energy of –804 kJ/mol and a heat of solution (in water) of –15 kJ/mol. RbF has a lattice energy of –768 kJ/mol and a heat of solution (in water) of –24 kJ/mol. Which salt forms stronger attractions with water?

(A) KF, because it releases more heat during the formation of crystal.
(B) KF, because it has a more negative heat of hydration.
(C) RbF, because it releases more heat during the formation of crystal.
(D) RbF, because it has a more negative heat of hydration.
(E) Both salts have the same interactions with water.

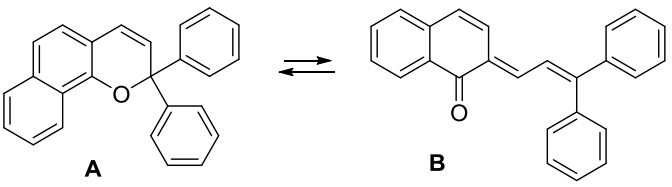
63. The reaction $2NO_2 \rightarrow 2NO + O_2$ obeys the rate law

$$\frac{\Delta[O_2]}{\Delta t} = 1.0 \times 10^{-2}\,[NO_2]^2 \text{ at 400 K.}$$

If the initial concentration of NO_2 is 1.00 *M*, how long will it take for the $[NO_2]$ to decrease to 0.25 *M* ?

(A) 50 s (B) 100 s (C) 200 s (D) 300 s (E) 600 s

64. Today's automatic sunglasses utilize the following rearrangement reaction between **A** and **B** promoted by UV:



However, infrared spectroscopy is often applied to differentiate **A** and **B** because of the strong and distinct absorption of _____ functional group.

(A) arene (B) conjugated olefin (C) carbonyl
(D) ether (E) amide

65. Water desalination is a method to solve the problem of drought resulting from climate change. What is the minimum pressure needed to purify the water from 0.05 M of NaCl(aq) by reverse osmosis at 27 °C? ($R = 0.08206$ L atm K^{-1} mol^{-1})

(A) 1.23 atm (B) 2.46 atm (C) 3.71 atm
(D) 4.52 atm (E) None of the above.

66. Consider the following reaction:

$A_2 + B_2 \rightarrow 2AB$ $\Delta H = -235$ kJ

The bond energy for A_2 is half the amount of AB. The bond energy of B_2 = 247 kJ/mol. What is the bond energy of A_2?

(A) 482 kJ/mol (B) 238 kJ/mol (C) 161 kJ/mol
(D) –118 kJ/mol (E) –129 kJ/mol

67. Which statement is ***correct***?

(A) The bond order of He_2^+ is 1. (B) The bond order of Ne_2 is 1.
(C) The bond order of C_2^+ is 1. (D) N_2 has a larger bond order than N_2^{2-}.
(E) None of the above.

68. You mix 265.0 mL of 1.20 *M* lead(II) nitrate with 300.0 mL of 1.55 *M* potassium iodide. Which of the followings is ***true***?

(A) Lead nitrate is the limited reagent.
(B) The final concentration of Pb^{2+} ions is 0.56 *M*.
(C) The final concentration of K^+ is 0.823 *M*.
(D) The final concentration of NO_3^- is 0.823 *M*.
(E) The final concentration of I^- is 0.823 *M*.

69. Follow the balanced equation: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

An equal number of moles of nitrogen and hydrogen gases were added in a balloon. The volume of the balloon is 2.00 L before any reaction occurs. Determine the volume of the balloon after the reaction is complete, assuming constant temperature.

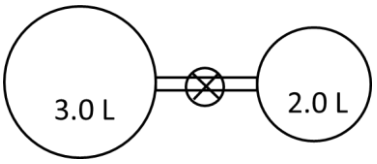
(A) 0.67 L (B) 1.00 L (C) 1.33 L (D) 2.00 L (E) 4.00 L

70. One beaker has 75.0 mL of a 2.00 *M* solution of $Na_2CrO_4(aq)$. Another one has 125 mL of a 2.00 *M* solution of $AgNO_3(aq)$. Please calculate the concentration of Ag^+ after the two solutions are mixed together.

(A) 0.00 *M* (B) 0.02 *M* (C) 0.75 *M* (D) 1.25 *M* (E) 0.50 *M*

71. Four identical 1.0 L flasks contain the gases He, Cl_2, CH_4, and NH_3, each at 0 °C and 1 atm pressure.
Which of the following statements is ***true***?
(A) He gas has the smallest average kinetic energy.
(B) Cl_2 gas has the highest density.
(C) CH_4 gas has the greatest number of molecules.
(D) NH_3 gas molecules collide elastically.
(E) All gas molecules have same average velocity.

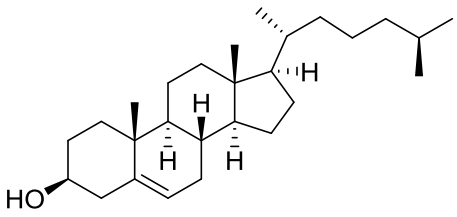
72. The valve between the 3.00 L bulb, in which the gas pressure is 2.00 atm, and the 2.00 L bulb, in which the gas pressure is 2.70 atm, is opened. What is the final pressure in the two bulbs, assuming the temperature remains constant?



(A) 0.71 atm (B) 1.03 atm (C) 1.62 atm (D) 2.01 atm (E) 2.28 atm

73. The concentration of a monoprotic acid is "**a**" *M* and the degree of dissociation of the acid is "**b**". What is its K_a?
(A) $b^2/(a-b)$ (B) $ab^2/(1-a)$ (C) $a^2b^2/(1+a)$ (D) $ab^2/(1-b)$ (E) $a^2b^2/(1-b)$

74. How many chiral centers are in the following structure?



(A) 6 (B) 7 (C) 8 (D) 9 (E) 10

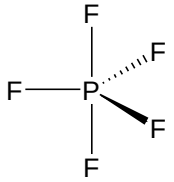
75. Compound X and Y contain two elements A and B only. 3.0 g of compound X contains 1.4 g of A, while 27.0 g of compound Y contains 7.0 g of A. The formula of compound X is AB. Which one is the formula of compound Y?
(A) AB_2 (B) A_4B_6 (C) A_2B (D) A_3B_4 (E) A_2B_5

76. What is the pH value of a 0.010 *M* solution of sodium azide (NaN_3)?
The K_a of $HN_3 = 1.0 \times 10^{-6}$
(A) 6.0 (B) 7.0 (C) 8.0 (D) 9.0 (E) 10.0

77. What is the net number of octahedral holes contained in the close packing of spheres unit cell like face-center cubic?
(A) 8 (B) 4 (C) 12 (D) 6 (E) 3

78. Reaction of potassium metal with excess $O_2(g)$ leads to $KO_2(s)$. Determine the oxidation state of the oxygen in $KO_2(s)$.
(A) +1 (B) –2 (C) –0.5 (D) +2 (E) –1

79. Determine the point group of the molecules shown below?



(A) C_{3v} (B) C_3 (C) D_{3d} (D) D_{3h} (E) None of the above.

80. Which charge of NO would have a bond order of 3?
(A) +1 (B) –1 (C) 0 (D) +2 (E) –2

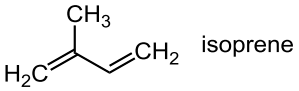
81. What is the energy required to excite the electron in the hydrogen atom from the n = 1 level to the n = 2 level? (R_H = 13.61 eV)
(A) 3.40 eV (B) 6.81 eV (C) 10.21 eV (D) 13.61 eV (E) None of the above.

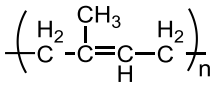
82. Using the data shown as follows to calculate $\Delta G°$ for the reaction (1 F = 96,485 coulombs): $Fe_{(s)} + Cu^{2+}_{(aq)} \rightarrow Fe^{2+}_{(aq)} + Cu_{(s)}$. The reduction potentials for Fe^{2+} and Cu^{2+} are as follows:
$Fe^{2+} + 2e^- \rightarrow Fe$ $\varepsilon° = –0.44$ V
$Cu^{2+} + 2e^- \rightarrow Cu$ $\varepsilon° = 0.34$ V
(A) $–1.9 \times 10^4$ J (B) $–1.5 \times 10^5$ J (C) 0 J
(D) 1.9×10^4 J (E) 1.5×10^5 J

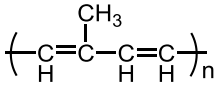
83. The net ionic equation that potassium iodide reacts with potassium iodate in the presence of HCl(aq) is $\mathbf{a}I^- + \mathbf{b}IO_3^- + \mathbf{c}H^+ \rightarrow \mathbf{d}I_2 + \mathbf{e}H_2O$. What is the sum of all coefficients (**a** + **b** + **c** + **d** + **e**)?
(A) 12 (B) 14 (C) 16 (D) 18 (E) 20

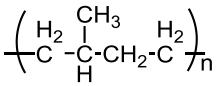
84. How many protons, neutrons, and electrons does the ion $^{18}O^{2-}$ have?
(A) 8 protons, 8 neutrons, 8 electrons (B) 8 protons, 18 neutrons, 8 electrons
(C) 8 protons, 10 neutrons, 10 electrons (D) 8 protons, 10 neutrons, 8 electrons
(E) 8 protons, 8 neutrons, 10 electrons

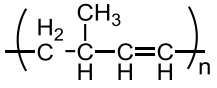
85. Nature rubber is a polymer derived from isoprene. What is the ***correct*** way to show the structure of rubber?

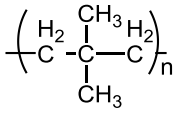


(A) 

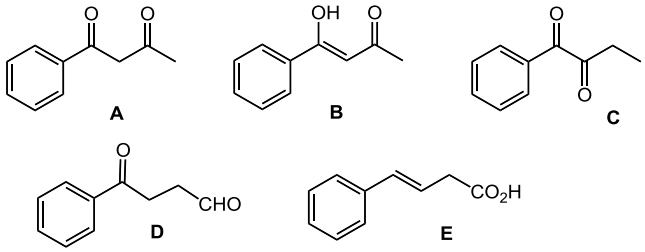
(B) 

(C) 

(D) 

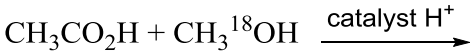
(E) 

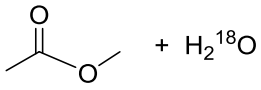
86. Which compound has the highest boiling point among the following structures?

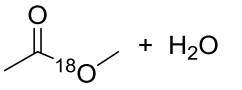


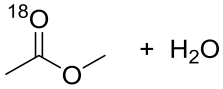
(A) A (B) B (C) C (D) D (E) E

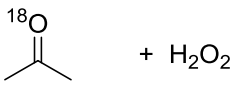
87. What are the products of the following reaction?

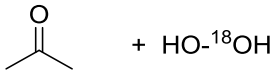


(A) 

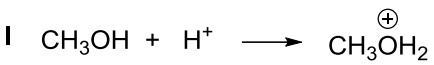
(B) 

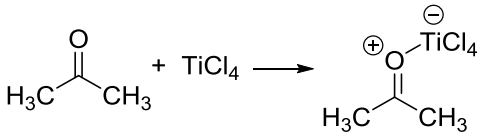
(C) 

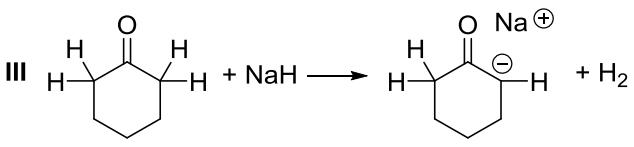
(D) 

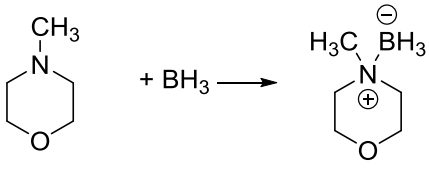
(E) 

88. Identify which of the reactions listed below are reactions between Brøsted–Lowry acids and bases.

I 

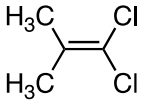
II 

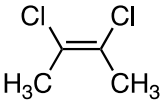
III 

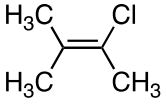
IV 

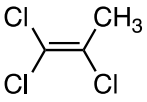
(A) I and II (B) I and III (C) III and IV (D) II and IV (E) I, III and IV

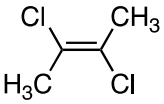
89. Which of the following molecules has zero net dipole moment?

(A) 

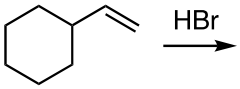
(B) 

(C) 

(D) 

(E) 

90. What is the product of the transformation listed below?



(A) 1-Bromo-2-cyclohexylethane
(B) 1-Bromoethylcyclohexane
(C) 1-Bromo-3-ethylcyclohexane
(D) 1-Bromo-2-ethylcyclohexane
(E) 1-Bromo-1-ethylcyclohexane