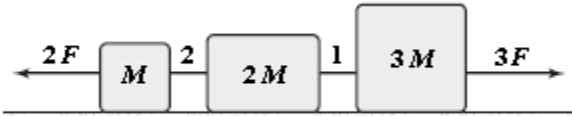說明:一、選擇題用 2B 鉛筆在「答案卡」上作答,修正時應以橡皮擦擦拭,不得使用修正液(帶),
　　　未遵照正確作答方法而致電腦無法判讀者,考生自行負責。
　　二、試題及答案卡必須繳回,不得攜出試場。

**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. The horizontal surface on which the objects slide is frictionless. If M = 5.0 kg, the tension in string 1 is 60 N. Determine F.
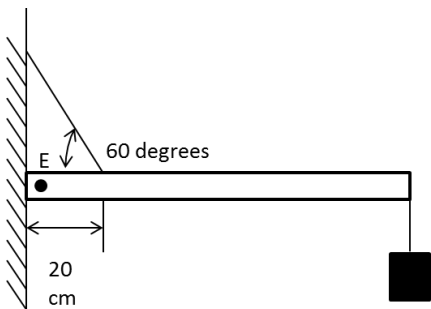

　(A)　20 N　　　　(B)　24 N　　　　(C)　30 N　　　　(D)　34 N　　　　(E)　48 N

2. The mass in the figure slides on a frictionless surface. If m = 2 kg, k_1 = 800 N/m, and k_2 = 450 N/m, what is approximate the frequency of oscillation (in Hz)?
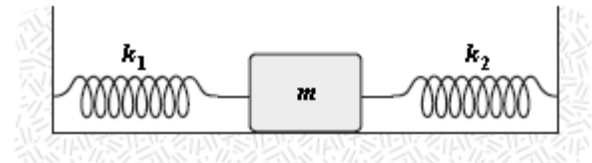

　(A)　2　　　　(B)　4　　　　(C)　6　　　　(D)　8　　　　(E)　10

3. A pivoted bar has a weight of 10 kg and a length of 1 meter, and is supported by a cable, as shown below. What is the tension force of the cable when a 50 N box is hung at the end of the bar?


　(A)　150 N　　　　(B)　295 N　　　　(C)　410 N　　　　(D)　570 N　　　　(E)　775 N

4. A circular track of radius 1000 meters is banked at 30 degrees without any friction. What is required speed for a car to keep running on the circular track?
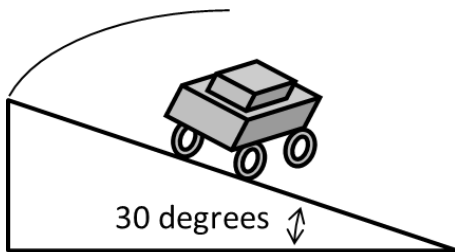
　(A)　about 30 m/s　　(B)　about 45 m/s　　(C)　about 55 m/s　　(D)　about 65 m/s　　(E)　about 75 m/s

5. Two point masses 1 kg and 2 kg are on a massless bar with axis of rotation through the center of length 2 meters, and a sphere of radius 10 cm and of mass 100 kg is on the center of the bar, as shown below. What is the moment of inertia (kg $\cdot$ m^2)?
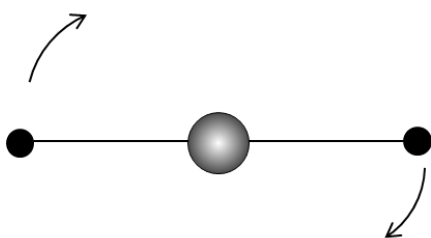
　(A)　3.33　　　　(B)　3.4　　　　(C)　3.5　　　　(D)　3.67　　　　(E)　4

6. The disk A with moment of inertia I_1 rotates with angular speed ω_1 about a vertical frictionless axle. A second disk B with moment of inertia I_2 rotates with angular speed ω_2 drops on the disk A. Since two disks are rough and two disks eventually reach the same angler speed ω, what is the final angular speed ω?
   (A) $(I_1\omega_1+ I_2\omega_2)/I_1$
   (B) $(I_1\omega_1)/(I_1+ I_2)$
   (C) $(I_1\omega_1+ I_2\omega_2)/(I_1+ I_2)$
   (D) $(I_2\omega_2)/(I_1+ I_2)$
   (E) $(I_1\omega_1- I_2\omega_2)/(I_1+ I_2)$

7. The same force F is applied horizontally to bodies 1, 2, 3, and 4, of masses m, 2m, 3m, and 4m, initially at rest and on a frictionless surface, until each body has traveled distance d. The correct listing of the magnitudes of the velocities of the bodies, $v1$, $v2$, $v3$, and $v4$ are _____.
   (A) $v_1 = v_2 = v_3 = v_4$
   (B) $v_1 = 2v_2 = 3v_3 = 4v_4$
   (C) $v_1 = \sqrt{2}v_2 = \sqrt{3}v_3 = 2v_4$
   (D) $v_1 = v_2/\sqrt{2} = v_3/\sqrt{3} = v_4/2$
   (E) $v_1 = v_2/2 = 2v_3/3 = 3v_4/4$

8. What is the entropy change for one mole ideal gas that expands from volume V to 4V in a free expansion process?
   (A) 4 R
   (B) 2 R
   (C) (ln4) R
   (D) (ln2) R
   (E) R

9. The superposition of two waves $y_1 = (0.007cm)cos\left[2\pi \left(\frac{156t}{s}\right)\right]$ and $y_2 = (0.007cm)cos\left[2\pi \left(\frac{150t}{s}\right)\right]$

   at the location x = 0 in space results in
   (A) Beats at a beat frequency of 6 Hz in a 153 Hz tone.
   (B) A tone at a frequency of 156 Hz, as well as beats at a beat frequency of 6 Hz in a 153 Hz tone.
   (C) Beats at a beat frequency of 3 Hz.
   (D) A pure tone at a frequency of 153 Hz.
   (E) A pure tone at a frequency of 156 Hz.

10. A diver swims from 2 meters to 10 meters below the surface of a lake. What is the pressure difference?
    (A) 54.5 kPa
    (B) 62.1 kPa
    (C) 78.4 kPa
    (D) 82.8 kPa
    (E) 98.2 kPa

11. A Carnot engine takes 2000 J of heat from a reservoir at 500 K, does some work, and discards some heat to reservoir at 300 K. What is its efficiency?
    (A) 0.2
    (B) 0.3
    (C) 0.4
    (D) 0.5
    (E) 0.6

12. A series of 3 uncharged concentric spherical conducting shells surround a small central charge q. The potential at a point outside the third shell, at distance r from the center, and relative to V = 0 at ∞, is
    (A) $-3k_eq/r$
    (B) $+3k_eq/r$
    (C) $-(ln\ 3)k_eq/r$
    (D) $+(ln\ 3)k_eq/r$
    (E) $+k_eq/r$

13. A conductor of radius r, length ℓ , and resistivity ρ has resistance R. It is melted down and formed into a new conductor, also cylindrical, with one fourth the length of the original conductor. The resistance of the new conductor is _____.
    (A) $\frac{1}{16}R$
    (B) $\frac{1}{4}R$
    (C) R
    (D) $4 R$
    (E) $16 R$

14. There is an electric dipole in an electric field, as shown below. Which of the following statement is **incorrect**?
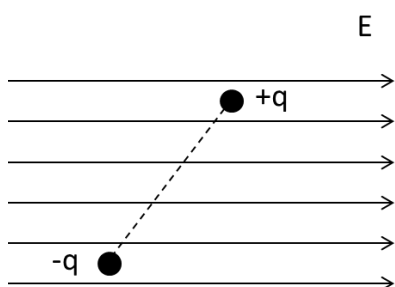

    (A) The dipole rotates clockwise.
    (B) The torque on +q points up.
    (C) The electric dipole moment is proportional to the distance from –q to +q.
    (D) The dipole has a max potential energy when it is perpendicular to E.
    (E) The electric dipole moment points from –q to +q.

15. A circuit contains a resistance and a charged capacitance. The resistance is 20 ohms, and the capacitance is 5 F. If the circuit is switched off, how long will it take when the current decreases to a half of initial value? (ln2 = 0.69)
    (A) 34 s
    (B) 50 s
    (C) 69 s
    (D) 100 s
    (E) 127 s

16. Using the rules of significant figures, calculate the following: 0.102 × 0.0821 × 273/1.01
    (A) 2.2635
    (B) 2.264
    (C) 2.26
    (D) 2.3
    (E) 2.66351

17. Which of the following best describes an orbital?
    (A) Space where electrons are likely to be found in an atom.
    (B) Space which may contain electrons, protons, and/or neutrons.
    (C) The space in an atom where an electron is most unlikely to be found.
    (D) Small, walled spheres that contain electrons.
    (E) A single space within an atom that contains all electrons of that atom.

18. Which of the following is the correct electron configuration for OF^- ?
    (A) $\sigma_{1s}^2 \sigma^*_{1s}^2 \sigma_{2s}^2 \sigma^*_{2s}^2 \sigma_{2p}^2 \pi_{2p}^2$
    (B) $\sigma_{1s}^2 \sigma^*_{1s}^2 \sigma_{2s}^2 \sigma^*_{2s}^2 \sigma_{2p}^2 \pi_{2p}^4 \pi^*_{2p}^2$
    (C) $\sigma_{1s}^2 \sigma^*_{1s}^2 \sigma_{2s}^2 \sigma^*_{2s}^2 \sigma_{2p}^2 \pi_{2p}^4 \pi^*_{2p}^4$
    (D) $\sigma_{1s}^2 \sigma^*_{1s}^2 \sigma_{2s}^2 \sigma^*_{2s}^2 \pi_{2p}^1$
    (E) None of the above.

19. Which of the following resonance structures is the most stable?

    (A)

    (B)

    (C)

    (D)

    (E) All of them are the same.
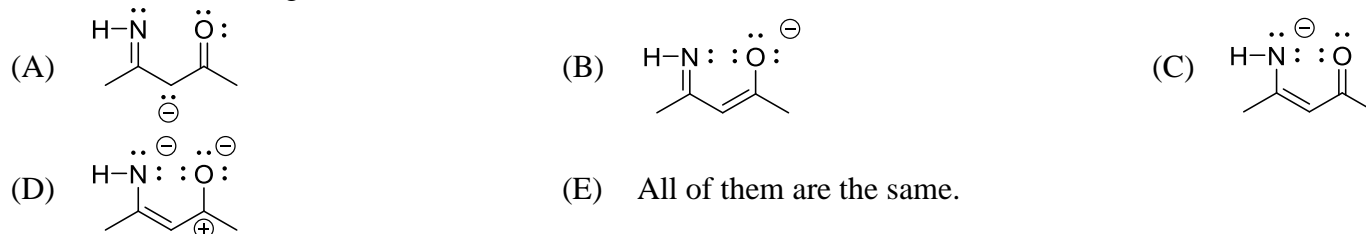
20. Which of the following does **NOT** contain at least one pi bond?
    (A) H_2CO
    (B) CO_2
    (C) C_2H_2
    (D) NO
    (E) All of the above (A-D) contain at least one pi bond.

21. Order the intermolecular forces (dipole-dipole, London dispersion, ionic, and hydrogen-bonding) from weakest to strongest.
    (A) dipole-dipole, London dispersion, ionic, and hydrogen-bonding
    (B) London dispersion, dipole-dipole, hydrogen-bonding, and ionic
    (C) hydrogen-bonding, dipole-dipole, London dispersion, and ionic
    (D) dipole-dipole, ionic, London dispersion, and hydrogen-bonding
    (E) London dispersion, ionic, dipole-dipole, and hydrogen-bonding

22. Which separation technique is based on differences in the affinity of the substances to be separated?
    (A) filtration
    (B) distillation
    (C) solvent extraction
    (D) paper chromatography
    (E) None of the above.

23. Which of the following gives correct rank of the ionization energies for Cs, Na, O, F, and S?
    (A) $Cs < Na < S < O < F$
    (B) $Cs < S < Na < O < F$
    (C) $F < O < Na < S < Cs$
   (D) $F < O < S < Na < Cs$
    (E) $Na < S < Cs < F < O$

24. Naturally occurring copper exists in two isotopic forms: ^{63}Cu and ^{65}Cu. The atomic mass of copper is 63.55 amu. What is the approximate natural abundance of ^{63}Cu?
    (A) 63%
    (B) 90%
    (C) 80%
    (D) 85%
    (E) 72%

25. The correct mathematical expression for finding the molar solubility(s) of $Al(OH)_3$ is _____.
    (A) $9 s^2 = K_{sp}$
    (B) $3 s^3 = K_{sp}$
    (C) $27 s^4 = K_{sp}$
    (D) $s^4 = K_{sp}$
    (E) $9 s^3 = K_{sp}$

26. Consider the following octahedral complex structures, each involving ethylene diamine and two different, unidentate ligands X and Y. Which, if any, of the following pairs are optical isomers?
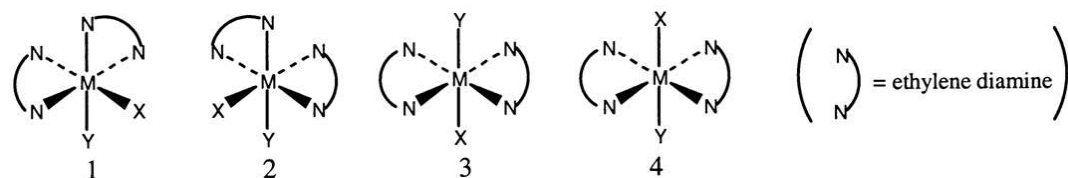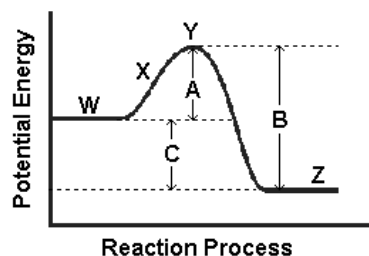

    (A) 1 and 4
    (B) 1 and 2
    (C) 3 and 4
    (D) 1 and 3
    (E) None of the above.

27. For which of the following processes would $\Delta S°$ be expected to be most positive?
    (A) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(g)$
    (B) $2NH_4NO_3(s) \rightarrow 2N_2(g) + O_2(g) + 4H_2O(g)$
    (C) $H_2O(l) \rightarrow H_2O(s)$
    (D) $N_2O_4(g) \rightarrow 2NO_2(g)$
    (E) $O_2(g) + 2H_2(g) \rightarrow 2H_2O(g)$

28. Why is this reaction considered to be exothermic?

    (A) Because energy difference A and energy difference C are about equal.
    (B) Because energy difference B is greater than energy difference C plus energy difference A.
    (C) Because energy difference A is greater than energy difference C.
    (D) Because energy difference B is greater than energy difference A.
    (E) Because energy difference B is greater than energy difference C.

29. The structure of pentose is shown on the down figure. How many carbon atoms with chirality are there in this molecule?
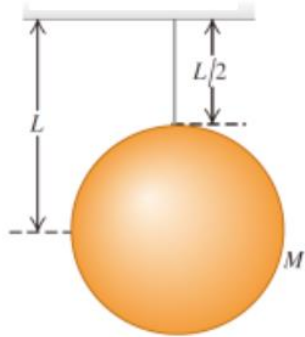
```
   CHO
H──┼──OH
H──┼──OH
H──┼──OH
  CH₂OH
```
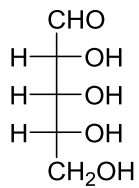
   (A)   1   (B)   2   (C)   3   (D)   4   (E)   5

30. Which one is Bragg equation?
   (A) $F = ma$ (B) $H\phi = E\phi$ (C) $n\lambda = 2d\sin\theta$ (D) $\Delta x \cdot \Delta p = h$ (E) $E = mc^2$

【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 uniform solid ball with mass M is supported by a massless rod. Derive the period of the pendulum with a small displacement.

   (A) $T = 2\pi (1.1L/g)^{1/2}$ (B) $T = 2\pi (1.8L/g)^{1/2}$ (C) $T = 2\pi (1.5L/g)^{1/2}$
   (D) $T = 2\pi (0.9L/g)^{1/2}$ (E) $T = 2\pi (0.7L/g)^{1/2}$

32. A rocket moving in space, far from all other objects, has a speed of v_i relative to the Earth. Its engines are turned on, and fuel is ejected in a direction opposite to the rocket's motion at a speed of v_{rel} relative to the rocket. What is the speed of the rocket, v_f relative to the earth once the rocket's mass is reduced to half its mass before ignition?
   (A) $v_i + v_{rel}\ln 2$ (B) $v_i + v_{rel}\ln(1/2)$ (C) $v_i + 2v_{rel}$ (D) $(v_i + v_{rel})/2$ (E) $v_i + v_{rel}/2$

33. A satellite is in a circular orbit and has a total mechanical energy of U. If the satellite lost half of its weight and doubled its radius of the circular orbit, what will be its total mechanical energy?
   (A)   1/4 U   (B)   1/2 U   (C)   U   (D)   2 U   (E)   4 U

34. A particle of mass m = 0.10 kg and speed v_0 = 5.0 m/s collides and sticks to the end of a uniform solid cylinder of mass M = 1.0 kg and radius R = 20 cm. If the cylinder is initially at rest and is pivoted about a frictionless axle through its center, what is the final angular velocity (in rad/s) of the system after the collision?
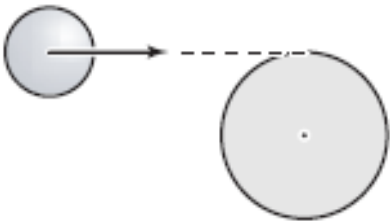
   (A)   2.0   (B)   4.2   (C)   6.1   (D)   8.1   (E)   10

35. A set of pulleys is used for supporting the calf (100 N). Please determine the weight of the subject in the right hand side.
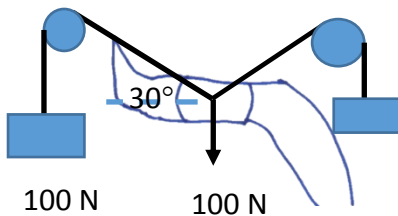
   (A)   50 N   (B)   73 N   (C)   100 N   (D)   141 N   (E)   173 N

36. Nadal received a shot with the tennis ball (60 g) travelling horizontally at 50 m/s, and returned the shot at 60 m/s horizontally in the opposite direction in 0.02 sec, what is the average force that Nadal suffered during this stroke?
   (A)   22 N   (B)   30N   (C)   180 N   (D)   330 N   (E)   550 N

37. The aluminum cylinder is 0.10 m² (cross-sectional area) and 0.35 m long. What is the force exerted on its ends if the elongation is 0.20 mm? (Young's modulus of aluminum is 7.0×10^{10} Pa)
   (A) 2.00×10^6 N   (B) 4.00×10^6 N   (C) 8.00×10^6 N   (D) 4.00×10^3 N   (E) 2.00×10^3 N

38. The wing of an airplane has an area of 1 m^2, and its wing thickness is 0.5 m. Air flows over the top at 20 m/s and under the wing at 10 m/s. The density of air is 1.2 kg/m^3. What is the net force on the wing due to Bernoulli effect? (Gravitational acceleration g = 10 m/s^2)

   (A) 12 N   (B) 15 N   (C) 18 N   (D) 183 N   (E) 186 N

39. A large tank of water has a hose connected to it. The tank is sealed at the top and has compressed air between the water surface and the top. When the water height h is 3.5 m the pressure of the compressed air is 4.0×10^5 Pa. Take the atmospheric pressure to be 1.0×10^5 Pa. What is the speed of the water when it flows out of the hose if h is 3.5 m?
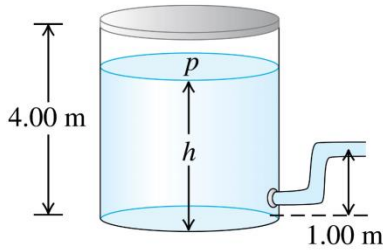
    (A) 30.8 m/s   (B) 28.4 m/s   (C) 26.8 m/s   (D) 25.5 m/s   (E) 23.4 m/s

40. A stainless steel container has a surface area of 0.5 m^2 and thickness of 2 cm. If the container is fully filled with 57°C hot-water and the temperature in the room is 27°C, what is the rate of energy loss through the container? (The thermal conductivity of stainless steel is 80 W/m/K)

    (A) 30 kW   (B) 60 kW   (C) 120 kW   (D) 180 kW   (E) 210 kW

41. A jack could lift a very heavy object like a car. It compressed air and exerts a force on a small piston of area 10 cm^2 and the pressure is transmitted by an incompressible liquid to a second piston of area 30 cm^2. If we want to lift a car weighting 1300 kg, what force must be exerted in the small area piston?

    (A) 43.3 N   (B) 424.6 N   (C) 433.3 N   (D) 1300.0 N   (E) 4247.7 N

42. An ambulance moves at a speed of 50 km/hr, and its siren emitting sound at a frequency of 5.0×10^2 Hz. What frequency of sound is heard by a runner who is running at 4 m/s approaching each other in the opposite direction (the speed of sound in air is 345 m/s)?

    (A) 47 Hz   (B) 475 Hz   (C) 506 Hz   (D) 527 Hz   (E) 555 Hz

43. One rope is wiggled with frequency f = 2.0 Hz, amplitude A = 1.0 m, and wave speed v = 4.0 m/s. What is the mathematical description of this wave?

    (A) $y(x, t) = \cos\pi (2x - t)$ (B) $y(x, t) = \cos\pi (2x + t)$ (C) $y(x, t) = \cos\pi (x - 2t)$

    (D) $y(x, t) = \cos\pi (x + 2t)$ (E) $y(x, t) = \cos\pi (x - 4t)$

44. There is a 1 kg gallium block and its melting point is around 30°C. What is the change of entropy when it was melted from solid to liquid at 30°C? (The fusion heat of gallium is L_f = 80.18 kJ/kg)

    (A) 0   (B) 0.265 kJ/K   (C) 0.374 kJ/K   (D) 2.673 kJ/K   (E) 3.779 kJ/K

45. Two charges of 15 pC and −40 pC are inside a cube with sides that are of 0.40 m length. Determine the net electric flux through the surface of the cube. ($\varepsilon_o = 8.85 \times 10^{-12}$ C^2/ N·m^2)

    (A) 2.8 N·m^2/C   (B) −2.8 N·m^2/C   (C) 1.1 N·m^2/C   (D) −1.1 N·m^2/C   (E) −0.47 N·m^2/C

46. A solid conducting sphere (radius = 5.0 cm) has a charge of 0.25 nC distributed uniformly on its surface. If point A is located at the center of the sphere and point B is 15 cm from the center, what is the magnitude of the electric potential difference between these two points? ($k_e = 9 \times 10^9$ N·m^2/C^2)

    (A) 15 V   (B) 23 V   (C) 30 V   (D) 45 V   (E) 60 V

47. A segment of wire of total length 2.0 m is formed into a circular loop having 5.0 turns. If the wire carries a 1.2-A current, determine the magnitude of the magnetic field at the center of the loop. ($\mu_0 = 4\pi \times 10^{-7}$ T· m/A)

    (A) 59 μT   (B) 69 μT   (C) 79 μT   (D) 89 μT   (E) 94 μT

48. A circuit consists of a capacitor and an inductor that are sequentially connected. If the capacitance is 0.5 mF and the inductance is 1 H, what is the resonance frequency of this circuit?

    (A) 23.4 rad/s   (B) 44.7 rad/s   (C) 50.5 rad/s   (D) 76.8 rad/s   (E) 87.6 rad/s

49. Three thin lenses with focal lengths 0.1 m, 0.2 m, and 0.3 m are placed next to each other. What is the equivalent focal length of a single lens?

   (A) 0.05 m   (B) 0.15 m   (C) 0.25 m   (D) 0.33 m   (E) 0.45 m

50. A cloud layer is 1000 m above the planet, with the area of 1×10^6 m^2, considered as the plates of a parallel-plate capacitor. If an electric field strength is greater than 3.0×10^6 N/C, it causes lightning, what is the maximum charge the cloud can hold?
($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N·m^2)

    (A) 28.55 C   (B) 26.55 C   (C) 24.55 C   (D) 22.55 C   (E) 20.55 C

51. Two isotopes leave the slit at point S and into a magnetic field of magnitude 0.100 T pointing into the page, each has speed of 1.00×10^6 m/s. The first one contain one proton and has a mass of 1.67×10^{-27} kg and the other contains a proton and a neutron and has a mass of 3.34×10^{-27} kg. What is the distance that they could be separated when they strike a photographic plate?
($e = 1.6 \times 10^{-19}$C)
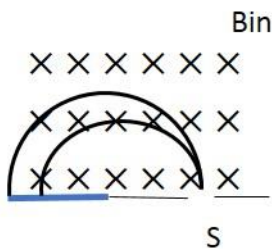
    (A) 0.520 m   (B) 0.313 m   (C) 0.210 m   (D) 0.105 m   (E) 0.104 m

52. If a farsighted patient's near point of eyes is 40 cm, what kinds of lens and focal length of a corrective lens have to enable the eye to see clearly an object 20 cm away?

    (A) converging lens, f = 13.3 cm   (B) diverging lens, f = 13.3 cm   (C) converging lens, f = 40 cm
    (D) diverging lens, f = 40 cm   (E) converging lens, f = 20 cm

53. There are two point-charges $-Q$, and $2Q$ located at the distance $2d$, and $4d$ from the origin O, respectively. What is the electric field at the origin O? (Vacuum permittivity is ε_0)
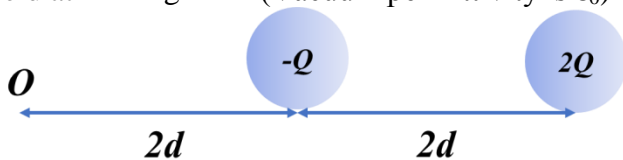
    (A) 0   (B) $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{d}$ (C) $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q^2}{2d^2}$

    (D) $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{8d^2}$ (E) $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{3Q}{8d^2}$

54. There is a cylindrical conductor with radius R which carries current I. Which diagram is correct for the magnetic field of this conductor?
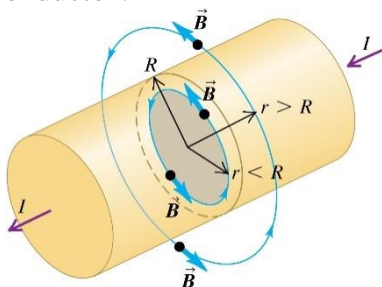
   (A)   (B)   (C)   (D)   (E)

55. There are two parallel, straight current-carrying conductors with current $I_1 = 10$ A and length $I_2 = 2$ A. Both of these two conductors are 1 m length, and the distance between them is 2 m. What is the force between these two parallel conductors? (Permeability constant is μ_0)

    (A) $F = \dfrac{10\mu_0}{\pi}$ (B) $F = \dfrac{5\mu_0}{\pi}$ (C) $F = \dfrac{2\mu_0}{\pi}$ (D) $F = \dfrac{5\mu_0}{2\pi}$ (E) $F = \dfrac{\mu_0}{2\pi}$

56. A medical blue light therapy laser treatment pen emits a blue light with wavelength of 415 nm in the visible light. The index of refraction for air and cornea is 1.00 and 1.34, respectively. What is the wavelength of this blue light when that enters into cornea from air? (Speed of light in vacuum is 3×10^8 m/s)

   (A) 185 nm   (B) 310 nm   (C) 486 nm   (D) 556 nm   (E) 693 nm

57. There is an ideal polarizer with the angle of $\phi = 60°$ between the polarizing axis and the vertical axis, and there is an ideal analyzer with the angle of $\phi = 0°$ between the polarizing axis and the vertical axis. When an unpolarized light with intensity I is incident on this ideal polarizer, what is its transmitted intensity?

    (A) 0.125 I (B) 0.250 I (C) 0.750 I (D) 0.866 I (E) 1.000 I

58. There is thin converging lens with focal length f = 140 mm. When an object is placed at the distance of 210 mm from the lens, what is the lateral magnification?

    (A) 0.3   (B) 0.5   (C) 1.0   (D) 2.0   (E) 3.0

59. The X-ray typically operate at a potential difference of 1.00×10^5 V. What is the minimum wavelength the X-ray tubes produce when electrons are accelerated through this potential difference? (The Planck's constant is 6.63×10^{-34} J·s)

    (A) 1.24×10^{-7} m   (B) 1.24×10^{-9} m   (C) 1.24×10^{-11} m   (D) 1.24×10^{-13} m (E) 1.24×10^{-15} m

60. In process *ab*, 20 J of heat is added to the system. In process *bd*, 80 J of heat is added to the system. Find the internal energy change ΔU in process *abd*.
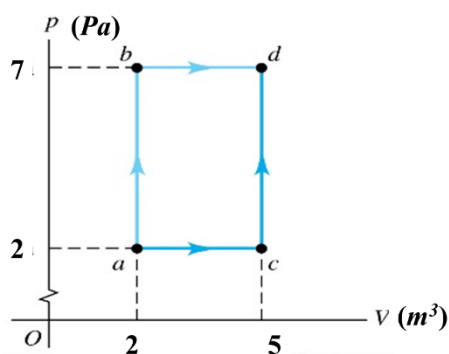
    (A) 21 J   (B) 59 J   (C) 79 J   (D) 101 J   (E) 121 J

61. Regarding the reactions of organic compounds, which of the following statements is **NOT** true?
    (A)   The reaction of benzene and chloromethane can produce toluene.
    (B)   Methanol is prepared in industry by the hydrogenation of carbon dioxide.
    (C)   The commercial production of ethanol is carried out by the reaction of water with ethylene.
    (D)   Aldehyde can be produced commercially by the oxidation of *primary* alcohol.
    (E)   Ketone can be produced commercially by the oxidation of *secondary* alcohol.

62. Consider the following data concerning the equation:

$$H_2O_2 + 3I^- + 2H^+ \rightarrow I_3^- + 2H_2O$$

	[H_2O_2]	[I^-]	[H^+]	rate
I	0.100 M	5.00×10^{-4} M	1.00×10^{-2} M	0.137 M/sec
II.	0.100 M	1.00×10^{-3} M	1.00×10^{-2} M	0.268 M/sec
III.	0.200 M	1.00×10^{-3} M	1.00×10^{-2} M	0.542 M/sec
IV.	0.400 M	1.00×10^{-3} M	2.00×10^{-2} M	2.084 M/sec

    (A) Rate = $k[H_2O_2][I^-][H^+]$ (B) Rate = $k[H_2O_2]^2[I^-]^2[H^+]^2$ (C) Rate = $k[I^-][H^+]$
    (D) Rate = $k[H_2O_2][H^+]$ (E) Rate = $k[H_2O_2][I^-]$

63. Which of the following statements are true? A catalyst can act in chemical reaction to:
    I.   Lower the activation energy.
    II.   Change the equilibrium concentration of the products.
    III.   Decrease ΔE for the reaction.
    IV.   Change the order of the reaction.
    V.   Provide a new path for the reaction.

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

64. Which of the following statements is true about the following electrochemical cell?
    Ca | Ca^{2+} (aq) || K$^+$ (aq) | K
    Ca^{2+} (aq) + 2e$^-$ → Ca(s); $\varepsilon° = -2.87$ V
    K$^+$ (aq) + e$^-$ → K(s); $\varepsilon° = -2.93$ V
    (A) The cell reaction is spontaneous with a standard cell potential of 0.06 V.
    (B) The cell reaction is nonspontaneous with a standard cell potential of -5.80 V.
    (C) The cell reaction is nonspontaneous with a standard cell potential of -0.06 V.
    (D) The cell reaction is spontaneous with a standard cell potential of 5.80 V.
    (E) The cell is at equilibrium.

65. Examine the phase diagram for the substance Bogusium (Bo) and select the correct statement.
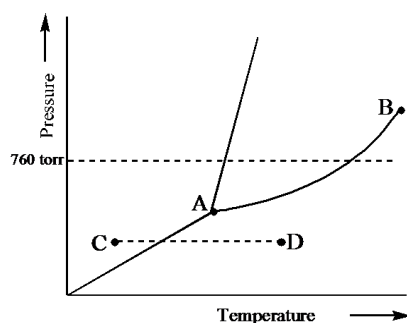

(A) Bo changes from a liquid to a gas as one follows the line from C to D.
(B) The triple point for Bo is at a higher temperature than the melting point for Bo.
(C) Bo changes from a solid to a liquid as one follows the line from C to D.
(D) Point B represents the critical temperature and pressure for Bo.
(E) Bo(s) has a lower density than Bo(l).

66. A 0.20 M solution of $MgSO_4$ has an observed osmotic pressure of 6.0 atm at 25°C. Determine the observed van't Hoff factor for this experiment.
(A) 1.23   (B) 2.00   (C) 1.66   (D) 1.80   (E) 1.45

67. Adipic acid contains 49.32% C, 43.84% O, and 6.85% H by mass. What is the empirical formula?
(A) $C_3H_5O_2$ (B) C_2HO_3 (C) $C_2H_5O_4$ (D) C_3HO_3 (E) $C_3H_3O_4$

68. On a new temperature scale (°L), water boils at 155.00°L and freezes at −10.00°L. Calculate the normal human body temperature using this temperature scale. On the Celsius scale, normal human body temperature is 37.0°C, and water boils at 100.0°C and freezes at 0.0°C.
(A) 57.30°L   (B) 47.35°L   (C) 51.05°L   (D) 61.05°L   (E) 41.05°L

69. When the following equation $C_2H_5OH + O_2 \rightleftharpoons CO_2 + H_2O$ is balanced, what are the coefficients?
(A) 2, 3, 1, 4   (B) 1, 3, 2, 3   (C) 1, 1, 1, 1   (D) 1, 2, 3, 4   (E) 1, 2, 2, 2

70. To form a buffer solution with pH = 9.0, how many moles of NH_4Cl should be added to 3.0 L of 0.20 M $NH_3(aq)$ at 25°C? (K_b of ammonia = 1.8×10^{-5}; assuming the volume of solution does not change after adding NH_4Cl)
(A) 0.36   (B) 0.72   (C) 1.08   (D) 3.6   (E) None of the above.

71. Which statement about hydrogen bonding is true?
(A) Hydrogen bonding is the intermolecular attractive forces between two hydrogen atoms in solution.
(B) The hydrogen bonding capabilities of water molecules cause $CH_3CH_2CH_2CH_3$ to be more soluble in water than CH_3OH.
(C) Hydrogen bonding of solvent molecules with a solute will not affect the solubility of the solute.
(D) Hydrogen bonding interactions between molecules are weaker than the covalent bonds within the molecule.
(E) Hydrogen bonding arises from the dipole moment created by the equal sharing of electrons within certain covalent bonds within a molecule.

72. How many effective atoms are there in a body-centered cubic unit cell?
(A) 1/2   (B) 1   (C) 2   (D) 3/2   (E) 3

73. Which of the following has a zero dipole moment?
(A) NH_3 (B) HCN   (C) PCl_5 (D) SO_2 (E) H_2O

74. An electron is promoted from the π to the π^* molecular orbital in an O_2 molecule following the absorption of a photon. Compared to the bond length in the non-excited molecule, the O_2 bond length will _____.
(A) be shorter   (B) be longer   (C) not be affected   (D) be same   (E) None of the above.

75. Determine the percent dissociation of a 0.18 M solution of hypochlorous acid, HClO. The K_a for the acid is 3.5×10^{-8}.
(A) 4.4×10^{-2} %   (B) 3.5×10^{-6} %   (C) 6.3×10^{-9} %   (D) 4.4×10^{-4} %   (E) 7.9×10^{-3} %

76. The solubility of $CaSO_4$ in pure water at 0 °C is 1.14 gram per liter. The value of the solubility product is _____.
(A) 7.01×10^{-5} (B) 8.37×10^{-3} (C) 7.01×10^{-2} (D) 8.37×10^{-5} (E) None of the above.

77. It is desired to determine the concentration of arsenic in a lake sediment sample by means of neutron activation analysis. The nuclide $^{75}_{33}As$ captures a neutron to form $^{76}_{33}As$, which in turn undergoes β decay. The daughter nuclide produces the characteristic γ rays used for the analysis. What is the daughter nuclide?
(A) $^{76}_{34}Se$ (B) $^{76}_{32}Ge$ (C) $^{74}_{31}Ga$ (D) $^{75}_{34}Se$ (E) $^{74}_{34}Se$

78. As shown below, compound IV can be prepared from reagents I, II, and III. Which of the following reaction conditions is the most suitable for the preparation of IV?
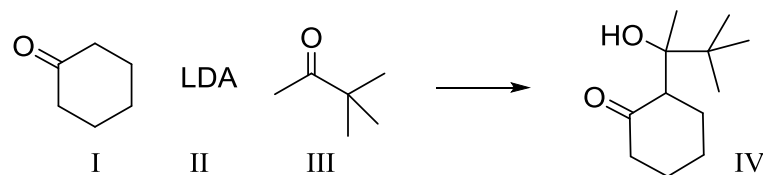
    I   II   III   IV

(A) I is slowly added to II, and III is then added to the above mixture.
(B) I is slowly added to II, and the resultant mixture is slowly added to III.
(C) II is slowly added to I, and III is then added to the above mixture.
(D) II is slowly added to I, and the resultant mixture is slowly added to III.
(E) I is slowly added to III, and II is then added to the above mixture.

79. The equilibrium constant of a certain reaction was measured at various temperatures to give the plot shown below. What is ΔS^o(J/mol·K) for the reaction? (R = 8.314 J/mol·K)
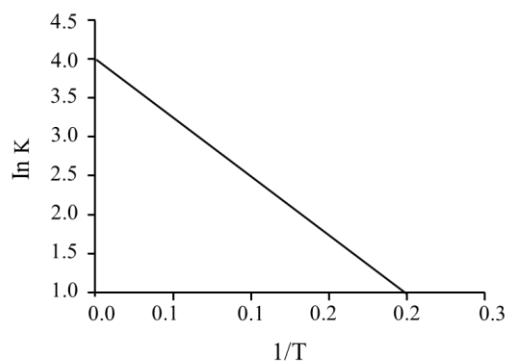

(A) 0.20   (B) 3.0   (C) −50   (D) $−8.3 \times 10^3$ (E) 33

80. For the reaction $N_2(g) + 2H_2(g) \rightarrow N_2H_4(l)$, if the percent yield for this reaction is 41.0%, what is the actual mass of hydrazine (N_2H_4) produced when 30.57 g of nitrogen reacts with 4.45 g of hydrogen?
    (A) 24.00 g   (B) 28.60 g   (C) 15.00 g   (D) 12.00 g   (E) 14.60 g

81. A sample of helium gas has been contaminated with argon gas. At 1 atm and 25°C, the density of the mixture is 0.200 g/L. What is the volume percent helium in the sample?
    (A) 90.0%   (B) 97.5%   (C) 80.3%   (D) 2.5%   (E) 99%

82. Which of the following is **NOT** a state function?
    (A) entropy   (B) enthalpy   (C) internal energy   (D) heat   (E) temperature

83. A metal ion in a high–spin octahedral complex has four more unpaired electrons than the same ion does in a low–spin octahedral complex. The metal ion could be:
    (A) V^{2+} (B) Cu^{2+} (C) Mn^{2+} (D) Cr^{3+} (E) Co^{2+}

84. Which of the following coordination compounds will form a precipitate when treated with an aqueous solution of $AgNO_3$?
    (A) $[Cr(NH_3)_3Br_3]$ (B) $[Mo(Cl)_2(NH_3)_4](NO_3)$ (C) $Na_3[WCl_6]$
    (D) $[Pt(NO^{linear})_2(OAc)_2](Br)_2$ (E) None of the above.

85. Which of the following species is diamagnetic?
    (A) CN   (B) B_2 (C) O_2
    (D) All of the above.   (E) None of the above.

86. Which of the lines in the figure below is the best representation of the relationship between the volume of a gas and its pressure, other factors remaining constant?
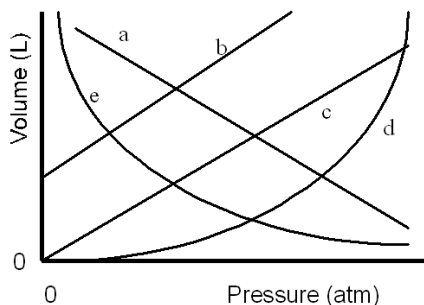
(A) a   (B) b   (C) c   (D) d   (E) e

87. Sulfur tetrafluoride adopts a see-saw geometry with two axial F atoms with a F–S–F angle of about 180° and two equatorial F atoms at about 90° from the axial fluorines. Which statement most accurately describes the axial and equatorial S–F bonds?
    (A) The axial S–F bonds are longer because the two fluorine atoms must share bonding to the same orbital on sulfur.
    (B) The axial S–F bonds are longer because they experience greater repulsion from the other fluorine atoms in the molecule.
    (C) The equatorial S–F bonds are longer because the equatorial F–S–F bond angle is the smallest in the molecule.
    (D) The equatorial S–F bonds are longer because they experience greater repulsion from the lone pair on sulfur.
    (E) The equatorial S–F bonds are longer because they experience greater repulsion from two axial fluorine atoms.

88. According to the Haber-Bosch process, which statement is true?
    (A) The reaction to produce NH_3 from H_2 and N_2 is reversible.
    (B) According to the Le Châtelier's principle, the overall reaction is favorable to produce products in the state of high pressure.
    (C) Increasing the reaction temperature can accelerate the reaction to equilibrium.
    (D) Using Fe as a catalyst can accelerate the reaction to equilibrium, but cannot change the equilibrium between the reagents and products.
    (E) All statement are true.

89. A sample of a washing powder that contains a mixture of Na_2CO_3 and $NaHCO_3$ is titrated with aqueous HCl and the following result is obtained:

mL HCl added
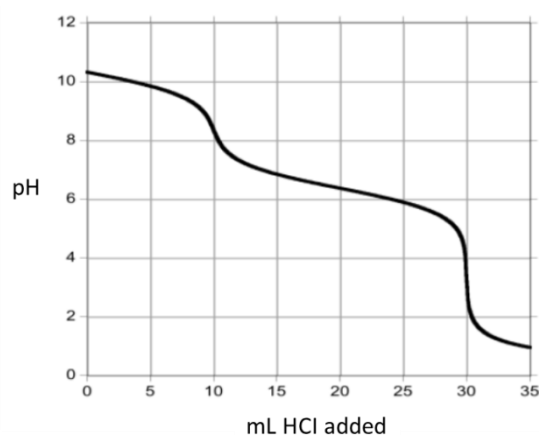
What is the mole ratio of CO_3^{2-} to HCO_3^{-} in the washing powder?
    (A) 2 mole CO_3^{2-} : 1 mole HCO_3^{-} (B) 1 mole CO_3^{2-} : 1 mole HCO_3^{-} (C) 1 mole CO_3^{2-} : 2 mole HCO_3^{-}
    (D) 1 mole CO_3^{2-} : 3 mole HCO_3^{-} (E) 3 mole CO_3^{2-} : 1 mole HCO_3^{-}

90. A student gave a molecule the following name:
    2-methyl-4-*t*-butylpentane
    However, the teacher pointed out that, although the molecule could be correctly drawn from this name, the name violates the IUPAC rules. What is the correct (IUPAC) name of the molecule?
    (A) 2-*t*-butyl-4-methylpentane   (B) 2,4,5,5-tetramethylhexane
    (C) 1-*sec*-butyl-1,2,2-trimethylpentane   (D) 2-*t*-butyl-4-*iso*-propylbutane
    (E) None of the above.