114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、試題本必須與答案十一併繳回,不得攜出試場。

本試題(含本封面)共16頁:第1頁

物理及化學試題

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 particle moves in a track and its speed are recorded and plotted in the figure. Which statement is **correct**?



- (B) It has maximum acceleration at t=1.5 seconds.
- (C) No external force acting on the particle at t>2.5 seconds.
- (D) The maximum force received by this particle is at t=1.5 seconds.
- (E) This particle received a constant force against its motion during 1.0 to 2.0 seconds.
- 2. A particle moves in simple harmonic motion according to $x = 2\sin(15t)$, where x is in meters and t is in seconds. Its **maximum** velocity in m/s is _____.
 - (A) $30\sin(15t)$ (B) $2\cos(15t)$ (C) 15
 - (D) 30 (E) None of the above.

3. Consider a very small hole in the bottom of a tank 20 cm in diameter filled with water to a height of 50 cm. Find the speed at which the water exits the tank through the hole.

(A) 3.1 m/s (B) 9.8 m/s (C) 31.3 m/s (D) 34.9 m/s (E) 980 m/s

4. A small object of mass m is suspended from a string of length L. The gravitational acceleration is g. The object revolves in a horizontal circle of radius r with constant speed. Find the period T of revolution.

(A)
$$\pi \sqrt{g \tan \theta / L}$$
 (B) $\pi \sqrt{L \sin \theta / g}$ (C) $2\pi \sqrt{L \cos \theta}$
(D) $2\pi \sqrt{g \sec \theta / L}$ (E) $\pi \sqrt{2g \cos \theta / L}$

5. A carnival merry-go-round rotates about a vertical axis at a constant rate. A man standing on the edge has a constant speed of 3.7 m/s and a centripetal acceleration \vec{a} of magnitude 1.8 m/s². Position vector \vec{r} locates him relative to the rotation axis. What is the magnitude of \vec{r} ?

(A) 3.5 m (B) 5.6 m (C) 6.4 m (D) 7.6 m (E) 12.4 m

6. A 2 kg object is subjected to three forces that give it an acceleration $\vec{a} = (-8 \text{ m/s}^2)\hat{i} + (6 \text{ m/s}^2)\hat{j}$. If two of the three forces are $\vec{F_1} = (30 \text{ N})\hat{i} + (16 \text{ N})\hat{j}$ and $\vec{F_2} = (-12 \text{ N})\hat{i} + (8 \text{ N})\hat{j}$, find the third force.

- (A) $(16 \text{ N})\hat{\imath} (12 \text{ N})\hat{\jmath}$ (B) $(-34 \text{ N})\hat{\imath} (12 \text{ N})\hat{\jmath}$ (C) $(20 \text{ N})\hat{\imath} + (12 \text{ N})\hat{\jmath}$
- (D) $(-34 \text{ N})\hat{\imath} + (12 \text{ N})\hat{\jmath}$ (E) $(20 \text{ N})\hat{\imath} + (18 \text{ N})\hat{\jmath}$



 θ/g

7. *n* moles of gas in a container of volume V_i at temperature *T* expands rapidly into an evacuated region after a membrane is broken. The final volume of the gas-occupied space is V_f . What is the change in thermal energy? (The universal gas constant is *R*.)

(A)
$$2nRT(V_f - V_i)/V_i$$
 (B) $nRT\ln(V_f/V_i)$ (C) $2nRT(V_f/V_i)$
(D) $2nRT\ln(2V_f/V_i)$ (E) $nRT(V_i + V_f)/V_f$

- 8. A medical defibrillator stores 320 J in a 40.0 μF capacitor. What is the voltage across the capacitor?
 (A) 2.8 V
 (B) 4.0 V
 (C) 2.8 kV
 (D) 4.0 kV
 (E) 2.8 MV
- 9. The figure shows three electric charges labeled Q₁, Q₂, Q₃, and some electric field lines in the region surrounding the charges. What are the signs of the three charges?



- (A) Q_1 is negative, Q_2 is positive, Q_3 is negative.
- (B) Q_1 is positive, Q_2 is positive, Q_3 is negative.
- (C) Q_1 is positive, Q_2 is negative, Q_3 is positive.
- (D) Q_1 is positive, Q_2 is negative, Q_3 is negative.
- (E) Q_1 is negative, Q_2 is negative, Q_3 is negative.
- 10. A particle experiences a force given by $F(x) = \alpha \beta x^3$. Find the potential energy U(x) of the particle. (Assume that the zero of potential energy is located at x = 0.)
 - (A) $U(x) = -\alpha x + \frac{\beta}{4} x^4$ (B) $U(x) = \alpha x \frac{\beta}{4} x^4$ (C) $U(x) = 3\beta x^2$
 - (D) $U(x) = -3\beta x^2$ (E) $U(x) = -6\beta x$
- 11. A DC voltage of 110 V is applied to a heater whose resistance is 15 Ohms when it is hot. At what rate is electrical energy transferred to thermal energy _____.

(A) 807 W (B) 1650 W (C) 8150 W (D) 12375 W (E) 24750 W

- 12. A wave has an angular frequency of 110 rad/s and a wavelength of 1.8 m. Calculate the angular wave number.
 - (A) 1.6 m^{-1} (B) 1.7 m^{-1} (C) 2.5 m^{-1} (D) 2.9 m^{-1} (E) 3.5 m^{-1}
- 13. A transverse wave traveling along a string transports energy at a rate *r*. If we want to double this rate, we could increase the amplitude of the wave by a factor of _____.
 - (A) 8 (B) 4 (C) 2 (D) $\sqrt{2}$ (E) $\sqrt{8}$

物理及化學試題

14. A 2.0 m string is f speed is 80 m/s. W	ixed at both ends an hat is the frequency of	d tightened until the of the standing wave	e wave shown	\bigotimes	XX	\rightarrow
in the figure?					2.0 m	
(A) 60 Hz	(B) 120 Hz	(C) 240 Hz	(D)	360 Hz	(E)	480 Hz

- 15. The speed of yellow light (from a sodium lamp) in a certain liquid is measured to be
 - 1.92×10^8 m/s. What is the index of refraction of this liquid for the light?
 - (A) 1.49 (B) 1.53 (C) 1.56 (D) 1.62 (E) 1.67

16. Which of the following statements is **incorrect**?

- (A) The emission spectrum of hydrogen contains a discontinuum of colors.
- (B) Diffraction produces both constructive and destructive interference.
- (C) All matter exhibits both particle and wavelike characteristics.
- (D) Niels Bohr developed a quantum model for the hydrogen atom.
- (E) None of the above.

17. Which of the following statements is **correct**?

- I. An excited atom can return to its ground state by emitting electromagnetic radiation.
- II. The energy of an atom is increased when electromagnetic radiation is emitted from it.
- III. The energy of electromagnetic radiation increases as its frequency increases.
- IV. An electron in the n=4 state in the hydrogen atom can go to the n=2 state by emitting electromagnetic radiation at the appropriate frequency.
- V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.
- (A) I, III, IV, V (B) III, V (C) I, II, III (D) III, IV, V (E) I, II, IV
- 18. Given K_a values of the following acids:

HClO ₄	HOAc	HCN	HF	
1×10^{7}	1.76×10^{-5}	4.93×10^{-10}	3.53×10^{-4}	

What is the order of increasing base strength?

- (A) $CN^{-} < F^{-} < OAc^{-} < ClO_{4}^{-}$ (B) $CN^{-} < OAc^{-} < F^{-} < ClO_{4}^{-}$
- (C) $CN^{-} < ClO_{4}^{-} < F^{-} < OAc^{-}$ (D) $ClO_{4}^{-} < OAc^{-} < F^{-}$
- (E) $ClO_4^- < F^- < OAc^- < CN^-$

19. The molecular formula of the ion is XF₃S³⁻, where X is an element from Group 6A. What is the hybridization of X atom?

(A) sp (B) sp^2 (C) sp^3 (D) dsp^3 (E) d^2sp^3

20. Which ion has the largest ionic size among the following?

(A) F^{-} (B) O^{2-} (C) Ca^{2+} (D) Te^{2-} (E) K^{+}

本試題(含封面)共16頁:第4頁

物理及化學試題

21. Compare the following molecules, what is the order of decreasing bond order?

1. N_2^+ 2. N_2 3. N_2^- (A)1=2=3(B)3>2>1(C)1>2>3(D)2>1=3(E)1=3>2

22. Which of the following statements is correct?

- (A) BF₃ has 24 total valence electrons, is an exception to the octet rule, and has resonance.
- (B) BF₃ has 24 total valence electrons, is an exception to the octet rule, and does not have resonance.
- (C) BF_3 has 24 total valence electrons, obeys the octet rule, and has resonance.
- (D) BF₃ has 22 total valence electrons, is an exception to the octet rule, and does not have resonance.
- (E) BF₃ has 24 total valence electrons, obeys the octet rule, and does not have resonance.

23. Which chemical process gives beer its brown color?

- (A) Maillard reaction (B) Caramelization (C) Oxidation of ethanol
- (D) Hydrolysis of starch (E) All of above
- 24. Arrange the following bonds in order of decreasing polarity:
 - 1.
 H-H
 2.
 C-F
 3.
 Al-F
 4.
 N-O

 (A)
 1>2>3>4
 (B)
 3>2>4>1
 (C)
 1>3>2>4

 (D)
 1>4>2>3
 (E)
 3>4>2>1
 (C)
 1>3>2>4

25. The density of a gas is 2 g/L at 3 atm and 27°C. What is the molar mass of the gas (g/mol)? (A) 1.48 (B) 32 (C) 149.6 (D) 9.3 (E) 16.4

26. Which of the following reactions does **not** involve oxidation-reduction?

- (A) $CH_4 + 3O_2 \longrightarrow 2H_2O + CO_2$ (B) $PCl_3 + Cl_2 \longrightarrow PCl_5$
- (C) $2Na + 2H_2O \longrightarrow 2NaOH + H_2$ (D) $MnO_2 + 4HCl \longrightarrow Cl_2 + 2H_2O + MnCl_2$
- (E) $CO_2 + 2LiOH \longrightarrow Li_2CO_3 + H_2O$

27. Calculate the standard change in enthalpy for the reaction and select the correct answer:

 $2Al_{(s)} + Fe_2O_{3(s)} \longrightarrow Al_2O_{3(s)} + 2Fe_{(s)}$ $\Delta H^{\circ}_{f} \text{ for } Fe_2O_{3(s)} = -826 \text{ kJ/mol} \qquad \Delta H^{\circ}_{f}$

- mol ΔH°_{f} for Al₂O_{3(s)} = -1676 kJ/mol
- (A) exothermic reaction
- (B) endothermic reaction
- (C) no energy change for this reaction
- (D) Lack of ΔH°_{f} for $Al_{(s)}$ and $Fe_{(s)}$ makes calculation impossible.
- (E) None of the above.

28. Which of the following can be identified as a set of isotopes?

Atomic nuclei contain

- I. 20 protons and 20 neutrons. II. 20 protons and 22 neutrons.
- III. 21 protons and 19 neutrons. IV. 20 neutrons and 18 protons.
- V. 21 protons and 20 neutrons.
- (A) I, IV and II, V (B) I, II and III, IV (C) I, III and II, V
- (D) II, IV and III, V (E) I, II and III, V

29. Which of the following represents the electron configuration for an excited state of an oxygen atom?

(A) $1s^22s^22p^4$ (B) $1s^22s^22p^5$ (C) $1s^22s^22p^33s^1$ (D) $1s^22s^22p^6$ (E) $1s^22s^22p^3$

30. The $^{238}_{92}$ U nucleus decays to form $^{206}_{82}$ Pb by producing α and β particles. What is the number of β particles produced?

(A) 1 (B) 2 (C) 4 (D) 6 (E) 8

【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 0.25 kg block oscillates on the end of the spring with a spring constant of 133.3 N/m. If the system has an energy of 6.0 J, then the amplitude of the oscillation is _____.

(A)	0.09 m	(B)	0.15 m	(C)	0.30 m	(D) 0.54 m	(E)	0.60 m
· /								

- 32. In designing buildings to be erected in an area prone to earthquakes, what relationship should the designer try to achieve between the natural frequency of the building and the typical earthquake frequencies?
 - (A) The natural frequency of the building should be exactly the same as typical earthquake frequencies.
 - (B) The natural frequency of the building should be very different from typical earthquake frequencies.
 - (C) The natural frequency of the building should be almost the same as typical earthquake frequencies but slightly higher.
 - (D) The natural frequency of the building should be almost the same as typical earthquake frequencies but slightly lower.
 - (E) No need to consider.

物理及化學試題

33. A 2 kg object is attached to an ideal massless horizontal spring of spring constant 100.0 N/m and is at rest on a frictionless horizontal table. The spring is aligned along the x-axis and is fixed to a peg in the table. Suddenly this mass is struck by another 2 kg object traveling along the x-axis at 3 m/s, and the two masses stick together. What are the amplitude and period of the oscillations that result from this collision?

(A)	0.30 m, 1.26 s	(B)	0.30 m, 0.88 s	(C)	0.42 m, 0.88 s
(D)	0.42 m, 1.26 s	(E)	0.42 m, 5.00 s		

34. Two blocks connected by a cord (of negligible mass) that passes over a frictionless pulley (also of negligible mass). The arrangement is known as Atwood's machine. One block has mass m_1 =1.3 kg; the other has mass m_2 =2.8 kg. What is the magnitude of the tension of the cord?

(A) 11.0 N (B) 12.8 N (C) 15.7 N (D) 17.7 N

35. A stuntman drives a car (without negative lift) over the top of a hill, and the cross section of which can be approximated by a circle of radius R = 1250 m. What is the greatest speed at which he can drive without the car leaving the road at the top of the hill? (Gravitational acceleration g = 10 m/s²) (A) 130 Km/h (B) 140 Km/h (C) 150 Km/h (D) 180 Km/h

36. A uniform and thin stick of mass (m) and length (l) is held vertically by two strings of negligible mass. Immediately after one string is cut, what is the magnitude of linear acceleration of the middle of the stick? (The moment of inertia of the thin stick is ml²/3 for an axis through one end.)

(A) g/4 (B) g/2 (C) 3g/4 (D) g

37. A uniformly charged ring with a radius of *a* is placed on the *xy* plane with its central axis aligned with the *z*-axis. If the total charge on the ring is *Q*, what is the electric field at $z = z_0$? ($k = 1/4\pi\varepsilon_0$, $F_{12} = kq_1q_2/r_{12}^2$)

(A) $kQ/(z_0^2 + a^2)^{1/2}$ (B) $kQz_0^2/(z_0^2 + a^2)^{5/2}$ (C) $kQa/(z_0^2 - a^2)^{3/2}$ (D) $kQ/(z_0^2 + a^2)$ (E) $kQz_0/(z_0^2 + a^2)^{3/2}$



(E)

 m_1

20.0 N

(E) 200 Km/h



Ź.

3g/2

(E)



物理及化學試題

38. A technician wearing a brass bracelet enclosing area 0.005 m^2 places her hand in a solenoid whose magnetic *B*-field is 7.0 T directed perpendicular to the plane of the bracelet. The resistance *R* around the bracelet's circumference is 0.02Ω . An unexpected power failure causes the field to drop to 1.5 T in a time interval of 20 ms. Estimate the power delivered to the bracelet.

39. The howler monkey is the loudest land animal and, under some circumstances, can be heard up to a distance of 8.9 km. Assume the acoustic output of a howler to be uniform in all directions and that the threshold of hearing is 1.0×10^{-12} W/m². A juvenile howler monkey has an acoustic output of 63 μ W. What is the ratio of the acoustic intensity produced by the juvenile howler to the reference intensity I_0 , at a distance of 200 m?

(A) 63 (B) 125 (C) 175 (D) 250 (E) 375

- 40. A parallel-plate capacitor without dielectrics is charged with $+Q_0$ and $-Q_0$ on their two metal plates, and the charging battery is disconnected. When a dielectric layer with a dielectric constant κ ($\kappa \ge 1$) is inserted to fill the gap between the two metal plates, what is the bound charge on the surface of the dielectric layer in contact with the metal plate?
 - (A) $Q_0(\kappa 1)/\kappa$ (B) $(\kappa 1)Q_0$ (C) $(2 \kappa)Q_0$ (D) $\kappa Q_0/(\kappa - 1)$ (E) $Q_0/(\kappa + 1)$

(C)

41. The human ear canal is, on average, 2.5 cm long. It is open to the outside and is closed at the other end by the eardrum. Estimate the frequencies (in the audible range) of the standing waves in the ear canal. Recall that, at 20°C, the speed of sound in air is about 343 m/s.

(B)

(A)

1715 Hz

Ossicles (middle ear bones): Malleus (anvil) Incus (hammer) Stapes (stirrup) Auditory canal Cochlea of inner ear Eardrum 13720 Hz 6860 Hz (D) (E) 20580 Hz q_2 q_1 Q

-

(E)

10 cm

-12 nC

 \propto

10 cm

(D) 12 nC

42. The charge Q is -3.0 nC. How much charge q_1 is needed to bring charge q_2 into static equilibrium?

3430 Hz

(A) -6 nC (B) 6 nC (C) 3 nC

- 43. A rectangular coil of N turns, each of width a and length b is in a magnetic field B directed into the page, with only half of the coil in the region of the magnetic field. The resistance of the coil is R. The coil can be moved to the right, up or down. What is the magnitude of the induced current if the coil is moved with a speed v down?
 - (A) 4NBav/R (B) NBavR (C) 2NBav/R (D) 2NBav (E) NBav/R

本試題(含封面)共16頁:第8頁

物理及化學試題

- 44. The surface water temperature in tropical oceans is above 25°C, and the deep-water temperature is about 4°C. If the Carnot engine is operated at these two temperatures, what is the **maximum** efficiency of this engine?
 - (A) 7 % (B) 9 % (C) 16 % (D) 84 % (E) 93 %
- 45. A cube of metal has an edge length of 10 cm. It has a density 3.0 g/cm³ and a specific heat 0.2 cal/g°C. When the internal energy of the cube increases by 9000 cal, its temperature increases by

(A)
$$9^{\circ}$$
C (B) 10° C (C) 12° C (D) 15° C (E) 20° C

46. Sound pressure level is defined as $SPL(dB) = 20 \log_{10}(P/P_0)$, where P is sound wave pressure and $P_0 = 20 \ \mu$ Pa. SPL decreases 6 dB as a listener's distance doubles from the sound source. The sound level is 110 dB at one meter away from the explosion of firecrackers. How far away would it be needed to reduce the sound level to an acceptable level of 80 decibels?

- (A) 5 m (B) 16 m (C) 32 m (D) 60 m (E) 100 m
- 47. A 5.0 L gas tank holds 1.7 mole of monoatomic helium (He) and 1.1 mole of diatomic oxygen (O₂), at a temperature of 260 K. The atomic masses of helium and oxygen are 4.0 g/mol and 16.0 g/mol, respectively. What is the ratio of the root-mean-square (thermal) speed of helium to that of oxygen?
 - (A) 1.4 (B) 2.0 (C) 2.8 (D) 4.0 (E) 5.6
- 48. A piece of thin uniform wire of mass m and length 3b is bent into an equilateral triangle. Find the moment of inertia of the wire triangle about an axis perpendicular to the plane of the triangle and passing through one of its vertices.

(A)
$$\frac{1}{3}mb^2$$
 (B) $\frac{1}{2}mb^2$ (C) $\frac{7}{12}mb^2$ (D) $\frac{2}{3}mb^2$ (E) $\frac{7}{4}mb^2$

49. One way to measure blood flow when blood vessels are exposed during surgery is to use an electromagnetic flowmeter. The device surrounds the blood vessel with an electromagnet to create a magnetic field perpendicular to the blood flow. Since blood is a modest conductor, a motional emf develops across the blood vessel. Given the vessel diameter d, magnetic field B, and voltage V measured across the vessel, what is the volume flow rate of blood?

(A) $\pi dV/(4B)$ (B) $\pi dV/(2B)$ (C) $\pi dV/B$ (D) $2\pi dV/B$ (E) $4\pi dV/B$

- 50. Suppose that 1 mole of an ideal gas undergoes a free expansion to three times its initial volume. What is the change of entropy? (The universal gas constant is R.)
 - (A) $2R \ln 2$ (B) $R \ln 2$ (C) $R \ln 3$ (D) $R \ln 4$ (E) $2R \ln 4$

物理及化學試題

- 51. A proton of mass m and charge q is in uniform circular motion perpendicular to a magnetic field B. The radius of the circle is r. What is the speed of the proton?
 - (A) qBr/3m (B) $2qBr^2/(2m(r+1))$ (C) $qBr^2/(2m(r+1))$ (D) qBr/2m (E) qBr/m

52. During each heartbeat, approximately 70 cm³ of blood is pushed from the heart at the mean arterial pressure of 100 mmHg. By assuming 72 beats per minute, what is the amount of external power output of the heart?

- (A) less than 0.20 W (B) 0.50 W (C) 0.84 W
- (D) 1.1 W (E) larger than 5.0 W

53. A square 10-turn coil with edge-length 50 cm carries a current of 2 A. It lies in the xy plane with magnetic moment in the z (\hat{k}) direction. It is placed in a uniform magnetic field $\vec{B} = 0.3\hat{i} + 0.4\hat{k}$ (T). What is the magnetic potential energy of the coil in the magnetic field?

(A) -2 Joule (B) -1.5 Joule (C) 1.5 Joule (D) 2 Joule (E) 2.4 Joule

54. An observer on the Earth measures the speed of spacecraft A to be 0.50*c* and the speed of spacecraft B to be -0.40*c*. What is the velocity of spacecraft B as observed by the crew on spacecraft A? (Here *c* is the speed of light. The Lorentz velocity transformation is $u'_x = \frac{u_x - v}{1 - \frac{v}{2}u_x}$)

(A) -c/6 (B) -3c/5 (C) -2c/5 (D) -c/4 (E) -3c/4

- 55. Two sources of light illuminate a double slit simultaneously. One has wavelength 570 nm and the second has an unknown wavelength. The fifth bright fringe (m=5) of the unknown wavelength overlaps the forth bright fringe (m=4) of the light of 570 nm wavelength. What is the unknown wavelength?
 - (A) 326 nm (B) 380 nm (C) 456 nm (D) 512 nm (E) 713 nm
- 56. A family member is ready to have a brain scan using technetium-99*, an excited isotope with 6.0hour half-life. The hospital makes this short-lived Tc-99* from the decay of molybdenum-99 then delivers it to the nuclear medicine department. After production of Tc-99*, the hospital staff takes 90 minutes to transport it to the operating room. What is an appropriate amount of Tc-99* to be produced by the technician-in-charge for the medical requirement of 10 mg of Tc-99*?

(A) 10 mg (B) 12 mg (C) 16 mg (D) 20 mg (E) 24 mg

57. 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?

(A) 1.41 eV (B) 1.70 eV (C) 2.82 eV (D) 3.11 eV (E) 4.51 eV

物理及化學試題

- 58. You wish to pick an element for a photocell that will operate via the photoelectric effect with visible light. Which of the following is suitable? ($hc/e=1.2398\times10^{-6}$ eV·m, the wavelength of visible light: $380 \sim 750$ nm)
 - (A) Silver (4.26 eV) (B) Copper (4.5 eV) (C) Aluminum (4.06 eV)
 - (D) Magnesium (3.66 eV) (E) Sodium (2.36 eV)
- 59. X-rays are produced by bombarding a tungsten target with high-energy electrons. The K-shell electron is ejected, and then an L-shell electron jumps to the K-shell and releases an X-ray photon. The binding energies of shell and orbital are listed in the table. Estimate the energy of this X-ray

photon

n.	Shell	Orbital	Binding Energy (keV)			
	K	1 S	69.525			
	L-1	2S	12.100			
	L-2	2P _{1/2}	11.544			
	L-3	2P _{3/2}	10.207			
10 ke	V (F	8) 12 keV	$V_{\rm c}$ (C) 58 keV (1)			

- (A) 10 keV (B) 12 keV (C) 58 keV (D) 69 keV (E) 81 keV
- 60. A beam of light with intensity 40 W/m² is polarized along the y-axis as shown. This beam passes through a polarizing filter with a polarization direction that makes an angle θ =60° with the y-axis. What is the intensity of the light transmitted through the filter?



- (A) 5 W/m^2 (B) 10 W/m^2 (C) 20 W/m^2 (D) 30 W/m^2 (E) 35 W/m^2
- 61. The observed osmotic pressure for a 0.10 M solution of M(SO₄)₂ at 27°C is 6.4 atm. Which of the following statements is **correct** regarding the expected and experimental values for *i*?
 - (A) $i_{\text{expected}}=3$, $i_{\text{experimental}}=2.6$ (B) $i_{\text{expected}}=4$, $i_{\text{experimental}}=3.6$
 - (C) $i_{\text{expected}}=3$, $i_{\text{experimental}}=3.6$ (D) $i_{\text{expected}}=4$, $i_{\text{experimental}}=2.6$
 - (E) $i_{\text{expected}}=2, i_{\text{experimental}}=2.6$

62. How many of the following given molecules have all their atoms lying in the same plane?
H₂C=CH₂, H₂C=C=CH₂, CH₃COCH₃, NH₃, CO₂, BeCl₂
(A) 2
(B) 3
(C) 4
(D) 5
(E) 6

物理及化學試題

- 63. The average osmotic pressure of human body fluids is approximately 7.7 atm. Suppose we want to prepare a solution of normal saline that is isotonic with human body fluids, using only NaCl as the solute. Assuming the density of the saline solution is 1 g/cm³ and the temperature is 37°C (normal body temperature), what would be the weight percent concentration of NaCl in this solution? (Assuming NaCl is 100% dissociation; Na=23.0 g/mol; Cl=35.5 g/mol)
 - (A) 0.45 % (w/w)(B) 0.90 % (w/w)(C) 1.35 % (w/w)(D) 1.80 % (w/w)(E) 2.30 % (w/w)
- 64. To cool 500 g of liquid water from 25°C to 0°C, what is the **minimum** number of ice cubes need to use? Each ice cube contains 20.0 g of water and temperature is -5°C. The enthalpy of fusion of ice is 6.020 kJ/mol; the heat capacity of liquid water is 75.4 J/mol·°C; the heat capacity of solid water is 2.05 J/g·°C.
 - (A) 6 (B) 7 (C) 8 (D) 9 (E) 10
- 65. In a coffee-cup calorimeter, 1.60 g NH₄NO₃ is mixed with 75.0 g water at an initial temperature 25.0°C. After dissolution of the salt, the final temperature of the calorimeter contents was 23.3°C. For the dissolving process, how many of the following thermodynamic functions: Δ H, Δ S_{sys}, Δ S_{surr}, and Δ S_{univ}, are positive in signs?
 - (A) 0 (B) 1 (C) 2 (D) 3 (E) 4

66. Methanol, a high-octane fuel, is extensively utilized in high-performance racing engines due to its favorable combustion characteristics. To investigate its thermodynamic properties, we can calculate the change in Gibbs free energy (ΔG°) associated with the combustion reaction of methanol when employed as an energy source. What is the ΔG° ? $\Delta G^{\circ}_{f}(CO_{2}) = -394 \text{ kJ}, \Delta G^{\circ}_{f}(H_{2}O) = -299 \text{ kJ}, \Delta G^{\circ}_{f}(CH_{3}OH) = -163 \text{ kJ}$

- (A) -1358 kJ/mol (B) -1558 kJ/mol (C) -1658 kJ/mol
- (D) -1758 kJ/mol (E) -1858 kJ/mol
- 67. In a high-spin octahedral complex, the metal ion has two more unpaired electrons than in a lowspin octahedral complex. What is the potential metal ion?
 - (A) V^{2+} (B) Cu^{2+} (C) Mn^{2+} (D) Cr^{3+} (E) Co^{2+}

68. Which of the following statements is incorrect?

- (A) An orbital can accommodate at most two electrons with the same spin quantum number.
- (B) The electron density at a point is disproportional to ψ^2 at that point.
- (C) The m_{ℓ} quantum number of an electron must be either $+ \frac{1}{2}$ or $-\frac{1}{2}$.
- (D) A 2p orbital is more penetrating than a 2s; i.e., it has a higher electron density near the nucleus and inside the charge cloud of a 1s orbital.
- (E) All of these are incorrect.

69. The solubility of the ionic compound M_2X_3 , having a molar mass of 288 g/mol, is 3.60×10^{-7} g/L at 25°C. What is the K_{sp} of the compound at 25°C?

(A) 1.40×10^{-11} (B) 6.54×10^{-31} (C) 2.70×10^{-45} (D) 3.30×10^{-43} (E) 1.69×10^{-16}

70. What is the pH of a 0.01 M MA solution where MA is a salt that fully dissociates into M⁺ and A⁻ in water? The acid dissociation constant (K_a) for its conjugate acid HA is 1.0×10^{-4}

(A) 5 (B) 6 (C) 7 (D) 8 (E) 9

71. What is the equilibrium concentration of HA²⁻ in a 1 M H₃A solution with the following dissociation constants?

 K_{a1} : 1.0×10^{-4} K_{a2} : 6.2×10^{-8} K_{a3} : 4.8×10^{-13} (A) 1.0×10^{-2} (B) 1.0×10^{-4} (C) 6.2×10^{-8} (D) 4.8×10^{-13} (E) 2.0×10^{-15}

72. A certain drug is metabolized in the human body following second-order kinetics, with the rate law given by: Rate= $k [D]^2$

where [D] is the concentration of the drug in mg/L, and k is the rate constant in $L \cdot mg^{-1} \cdot min^{-1}$. At time t=0, the drug concentration in the bloodstream is 20.0 mg/L. After 30.0 min, the concentration drops to 10.0 mg/L.

How long will it take for the concentration to drop to 5.0 mg/L?

(A) 60.0 min (B) 45.0 min (C) 37.5 min (D) 90.0 min (E) 120.0 min

73. The balanced equation for the reaction of the gases nitrogen dioxide and fluorine is

 $2NO_{2(g)} + F_{2(g)} \longrightarrow 2NO_2F_{(g)}$ (rate constant: k)

A suggested mechanism for this reaction is

 $NO_{2(g)} + F_{2(g)} \longrightarrow NO_2F_{(g)} + F_{(g)}$ (rate constant: k_1)

 $F_{(g)} + NO_{2(g)} \longrightarrow NO_2F_{(g)}$ (rate constant: k_2)

If the first step is the rate-determining step, which of the following expressions **correctly** represents the rate law?

- (A) Rate= $k [NO_2]^2 [F_2]$ (B) Rate= $k [NO_2] [F_2]$ (C) Rate= $k_2 [NO_2] [F]$
- (D) Rate= k_1 [NO₂][F₂] (E) None of the above.

74. Consider the ammonia synthesis reaction: $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$

where $\Delta G^{\circ} = -31.3 \text{ kJ/mol of } N_2 \text{ consumed at } 25^{\circ}\text{C}$

Which of the following statements correctly predicts the direction of the reaction when

 $P_{N_2} = P_{H_2} = P_{NH_3} = 1.00$ atm?

- (A) the system moves to the right
- (B) the system moves to the left
- (C) the system is already at equilibrium
- (D) the system moves to the left if the temperature increases
- (E) not enough information

- 75. What is the solubility of solid CaF2 ($K_{sp} = 4 \times 10^{-11}$) in a 0.10 M NaF solution?(A) 4×10^{-11} (B) 4×10^{-9} (C) 2×10^{-6} (D) 2×10^{-9} (E) 4×10^{-6}
- 76. In a real gas system, the van der Waals equation is used to consider gas behaviors. van der Waals equation is written as: $[P + a(n^2/V^2)](V nb)=nRT$

Which of the kinetic molecular theory postulates is **incorrect** in a real gas system so that the correction factor of pressure is required? P=observed pressure, T=temperature, V=volume of the container, n=mole of the gas, a and b=van der Waals constants, and R=Avogadro constant. $a(n^2/V^2)$ =correction factor of pressure compared to the ideal gas law.

- (A) The particles in a gas are in constant, random motion.
- (B) The combined volume of the particles is negligible.
- (C) The particles exert no forces on one another.
- (D) Any collisions between the particles are completely elastic.
- (E) The average kinetic energy of the particles is proportional to the temperature in Kelvins.
- 77. Three electrochemical cells were connected in series so that the same quantity of electrical current passes through all three cells. In the first cell, 1.15 g of chromium metal was deposited from a chromium(III) nitrate (Cr(NO₃)₃) solution. In the second cell, 6.31 g of osmium was deposited from a solution made of Osⁿ⁺ and nitrate ions.

Choose the **correct** name of the salt. Cr=52.0 g/mol; Os=192.2 g/mol

- (A) osmium(II) nitrate (B) osmium(III) nitrate (C) osmium(IV) nitrate
- (D) osmium(V) nitrate (E) osmium(VI) nitrate
- 78. A pain relief medication indicates that every 6 g of powder contains approximately 480 mg of ibuprofen. Assuming all of the active ingredients are ibuprofen, the powder is fully dissolved in 0.5 L of isopropanol. What is the approximate concentration of ibuprofen in the resulting solution in ppm? (The density of isopropanol is 0.79 g/cm³.)
 - (A) 0.12 ppm (B) 480 ppm (C) 960 ppm (D) 1215 ppm (E) 1304 ppm
- 79. Consider the molecular orbital energy level diagrams for O₂ and NO. Which of the following statement is **correct**?
 - I. Both molecules are paramagnetic.
 - II. The bond strength of O_2 is greater than the bond strength of NO.
 - III. NO is an example of a heteronuclear diatomic molecule.
 - IV. The ionization energy of NO is smaller than the ionization energy of NO^+ .
 - (A) I only (B) I and II (C) I and III (D) II and III (E) I, III, and IV



84. Which of the following becomes more soluble in water upon addition of NaOH?

- (A) an amine (B) a carboxylic acid (C) a phenol
- (D) an alkane (E) two of these





(D) $\overset{\mathsf{CH}_3}{\longleftarrow} \overset{\mathsf{CH}_3}{\longleftarrow} \overset{\mathsf{CH}_3}{\longleftrightarrow} \overset{\mathsf{CH}_3}$

90. If a 20.0 g sample of CaCO3 is put into a 20.0 L container and heated to 800°C, what the mass
percentage of the CaCO3 will react to reach equilibrium? (Ca=40.08 g/mol), $K_P = 1.16$ at 800°C,
CaCO3(s) \longrightarrow CaO(s) + CO2(g)
(A) 100% (B) 76% (C) 50% (D) 24% (E) 13%