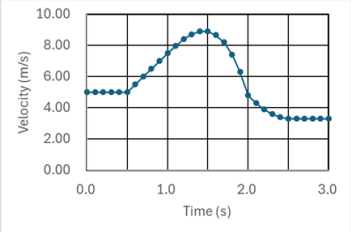
114 學年度學士後醫學系招生考試
物理及化學試題

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**?

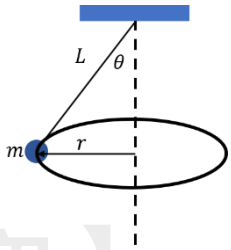


(A) It is stationary from t=0.0 to t=0.5 second.
(B) It has maximum acceleration at t=1.5 seconds.
(C) No external force acting on the particle at t>2.5 seconds.
(D) The maximum force received by this particle is at t=1.5 seconds.
(E) This particle received a constant force against its motion during 1.0 to 2.0 seconds.

2. A particle moves in simple harmonic motion according to x = 2sin(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) $2\pi\sqrt{L\cos\theta/g}$
(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/s^2. 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 $\vec{a} = (-8\,\text{m/s}^2)\hat{\imath} + (6\,\text{m/s}^2)\,\hat{\jmath}$. If two of the three forces are $\vec{F}_1 = (30\,\text{N})\hat{\imath} + (16\,\text{N})\hat{\jmath}$ and $\vec{F}_2 = (-12\,\text{N})\hat{\imath} + (8\,\text{N})\hat{\jmath}$, 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) $(20\,\text{N})\hat{\imath} + (18\,\text{N})\hat{\jmath}$

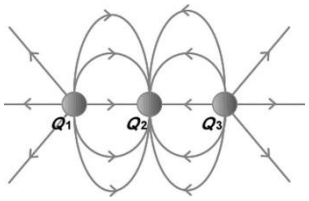
7. n moles of gas in a container of volume V_i at temperature T expands rapidly into an evacuated region after a membrane is broken. The final volume of the gas-occupied space is V_f. What is the change in thermal energy? (The universal gas constant is R.)

(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 Q_1, Q_2, Q_3, 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

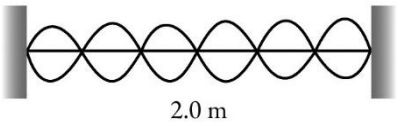
12. A wave has an angular frequency of 110 rad/s and a wavelength of 1.8 m. Calculate the angular wave number.

(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) $\sqrt{8}$

14. A 2.0 m string is fixed at both ends and tightened until the wave speed is 80 m/s. What is the frequency of the standing wave shown in the figure?



(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 $1.92 \times 10^8 \mathrm{m/s}$. 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) $ClO_4^- < OAc^- < CN^- < F^-$
(E) $ClO_4^- < F^- < OAc^- < CN^-$

19. The molecular formula of the ion is XF_3S^{3-}, 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^+

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

25. The density of a gas is 2 g/L at 3 atm and 27ºC. 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:

$2Al_{(s)} + Fe_2O_{3(s)} \longrightarrow Al_2O_{3(s)} + 2Fe_{(s)}$

$\Delta H°_f$ for $Fe_2O_{3(s)}$ = -826 kJ/mol $\Delta H°_f$ for $Al_2O_{3(s)}$ = -1676 kJ/mol

(A) exothermic reaction
(B) endothermic reaction
(C) no energy change for this reaction
(D) Lack of $\Delta H°_f$ 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) $1s^2 2s^2 2p^4$ (B) $1s^2 2s^2 2p^5$ (C) $1s^2 2s^2 2p^3 3s^1$
(D) $1s^2 2s^2 2p^6$ (E) $1s^2 2s^2 2p^3$

30. The $^{238}_{92}\mathrm{U}$ nucleus decays to form $^{206}_{82}\mathrm{Pb}$ 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

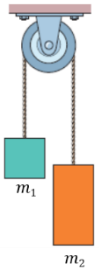
32. In designing buildings to be erected in an area prone to earthquakes, what relationship should the designer try to achieve between the natural frequency of the building and the typical earthquake frequencies?

(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.

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?

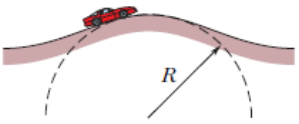
(A) 0.30 m, 1.26 s (B) 0.30 m, 0.88 s (C) 0.42 m, 0.88 s
(D) 0.42 m, 1.26 s (E) 0.42 m, 5.00 s

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?



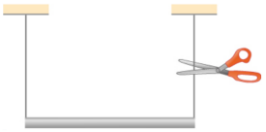
(A) 11.0 N (B) 12.8 N (C) 15.7 N (D) 17.7 N (E) 20.0 N

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 $R = 250$ 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/s^2)



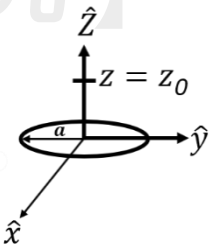
(A) 130 Km/h (B) 140 Km/h (C) 150 Km/h (D) 180 Km/h (E) 200 Km/h

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 ml^2/3 for an axis through one end.)



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

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) $kQz_0/(z_0^2 + a^2)^{3/2}$

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 0.02 Ω. 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.

(A) 23.6 W (B) 31.5 W (C) 47.3 W (D) 63.1 W (E) 94.6 W

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/m^2. A juvenile howler monkey has an acoustic output of 63 μW. 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?

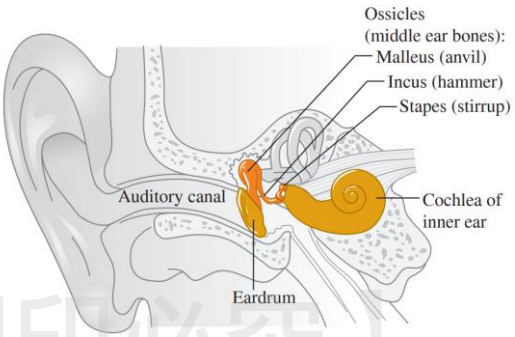
(A) 63 (B) 125 (C) 175 (D) 250 (E) 375

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 $(\kappa \geq 1)$ 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) $(2-\kappa)Q_0$

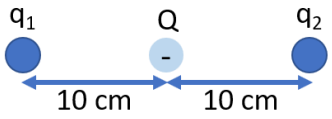
(D) $\kappa Q_0/(\kappa-1)$ (E) $Q_0/(\kappa+1)$

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.



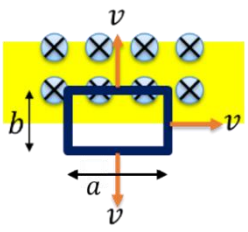
(A) 1715 Hz (B) 3430 Hz (C) 6860 Hz (D) 13720 Hz (E) 20580 Hz

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



(A) -6 nC (B) 6 nC (C) 3 nC (D) 12 nC (E) -12 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) $NBav/R$

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/cm^3 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°C (B) 10°C (C) 12°C (D) 15°C (E) 20°C

46. Sound pressure level is defined as $\mathrm{SPL(dB)} = 20\log_{10}(\mathrm{P}/\mathrm{P}_0)$, where P is sound wave pressure and $\mathrm{P}_0 = 20$ μPa. 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 (O_2), 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 3*b* 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) $4\pi dV/B$

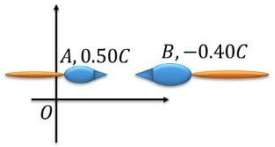
50. Suppose that 1 mole of an ideal gas undergoes a free expansion to three times its initial volume. What is the change of entropy? (The universal gas constant is R.)
(A) $2R\ln 2$ (B) $R\ln 2$ (C) $R\ln 3$ (D) $R\ln 4$ (E) $2R\ln 4$

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 cm^3 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 $\vec{B} = 0.3\hat{\imath} + 0.4\hat{k}$ (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 $0.50c$ and the speed of spacecraft B to be -0.40c. 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 $u'_x = \frac{u_x - v}{1 - \frac{v}{c^2}u_x}$)



(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 6.0-hour 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

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=1.2398×10^{-6} eV·m, the wavelength of visible light: 380 ~ 750 nm)

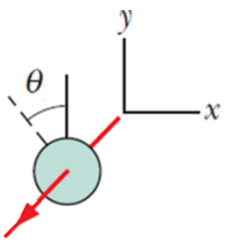
(A) Silver (4.26 eV) (B) Copper (4.5 eV) (C) Aluminum (4.06 eV)
(D) Magnesium (3.66 eV) (E) Sodium (2.36 eV)

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.

Shell	Orbital	Binding Energy (keV)
K	1S	69.525
L-1	2S	12.100
L-2	$2P_{1/2}$	11.544
L-3	$2P_{3/2}$	10.207

(A) 10 keV (B) 12 keV (C) 58 keV (D) 69 keV (E) 81 keV

60. A beam of light with intensity 40 W/m^2 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 $M(SO_4)_2$ at 27°C is 6.4 atm. Which of the following statements is **correct** regarding the expected and experimental values for i?

(A) $i_{expected}$=3, $i_{experimental}$=2.6 (B) $i_{expected}$=4, $i_{experimental}$=3.6
(C) $i_{expected}$=3, $i_{experimental}$=3.6 (D) $i_{expected}$=4, $i_{experimental}$=2.6
(E) $i_{expected}$=2, $i_{experimental}$=2.6

62. How many of the following given molecules have all their atoms lying in the same plane?
$H_2C{=}CH_2$, $H_2C{=}C{=}CH_2$, CH_3COCH_3, NH_3, CO_2, $BeCl_2$

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

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/cm^3 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 NH_4NO_3 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: ΔH, ΔS_{sys}, ΔS_{surr}, and ΔS_{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 ($\Delta G°$) associated with the combustion reaction of methanol when employed as an energy source. What is the $\Delta G°$?
$\Delta G°_f$ (CO_2) = -394 kJ, $\Delta G°_f$ (H_2O) = -299 kJ, $\Delta G°_f$ (CH_3OH)= -163 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 low-spin 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 2*p* orbital is more penetrating than a 2*s*; i.e., it has a higher electron density near the nucleus and inside the charge cloud of a 1*s* 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 HA^{2-} in a 1 M H_3A 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 $[NO_2][F_2]$ (E) None of the above.

74. Consider the ammonia synthesis reaction: $N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)}$
where ΔG^o = -31.3 kJ/mol of N_2 consumed at 25°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 CaF_2 (K_{sp} =4×10^{-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}

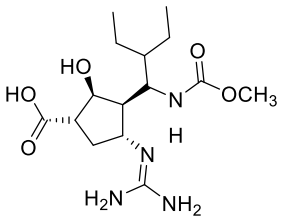
76. In a real gas system, the van der Waals equation is used to consider gas behaviors. van der Waals equation is written as: $[P + a(n^2/V^2)](V - nb)=nRT$
Which of the kinetic molecular theory postulates is **incorrect** in a real gas system so that the correction factor of pressure is required? P=observed 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 ($Cr(NO_3)_3$) solution. In the second cell, 6.31 g of osmium was deposited from a solution made of Os^{n+} 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/cm^3.)
(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 O_2 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

80. Peramivir has shown to be effective against the influenza B virus.
What is the degree of unsaturation in Peramivir?

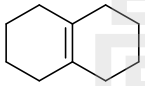


(A) 2 (B) 3 (C) 4 (D) 5 (E) 6

81. Which of the following cycloalkenes would be expected to be stable?

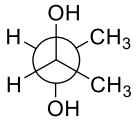

I

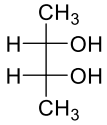

II


III

(A) I and II (B) II and III (C) II (D) I and III (E) All are stable.

82. What is the structural relationship of the following two compounds?





(A) same compound (B) enantiomers (C) *cis-trans* isomers
(D) structural isomers (E) diastereomers

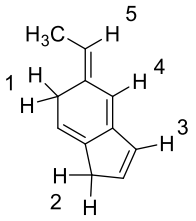
83. Two complex ions containing Ni are $[Ni(NH_3)_6]^{2+}$, which is blue, and $[Ni(en)_3]^{2+}$, which is purple.
Which one of these statements is **correct**? (en = $H_2N–CH_2–CH_2–NH_2$)

(A) The wavelength of the light absorbed by $[Ni(en)_3]^{2+}$ is greater than the wavelength absorbed by $[Ni(NH_3)_6]^{2+}$.
(B) The energy of the photon absorbed by $[Ni(en)_3]^{2+}$ is greater than that absorbed by $[Ni(NH_3)_6]^{2+}$.
(C) Both complex ions are diamagnetic.
(D) $[Ni(en)_3]^{2+}$ absorbs light in the violet region of the spectrum.
(E) The crystal field splitting energy (Δ) is greater for $[Ni(NH_3)_6]^{2+}$ than for $[Ni(en)_3]^{2+}$.

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

85. Given the compound as shown below:



Which of the labeled H atoms (1-5) in the following molecule would be predicted to be the **most** acidic?

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

86. Which of the following compounds exhibits the **highest** stability?

(A) 2-methyl-1,2-pentadiene (B) (*Z*)-2-methyl-1,3-pentadiene
(C) (*E*)-2-methyl-1,3-pentadiene (D) 2-methyl-2,3-pentadiene
(E) 2-methyl-1,4-pentadiene

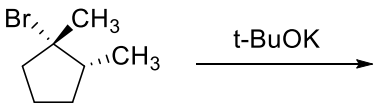
87. A metal fluoride crystallizes in a close-packed arrangement of fluoride ions, with the metal ions occupying one-half of the octahedral holes. What is the formula of this compound?

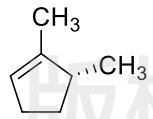
(A) MF (B) MF_2 (C) MF_3 (D) M_2F (E) M_2F_3

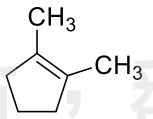
88. As indicated by Lewis structures, which of the following species could **not** comply with the octet rule? I. NO; II. NO_2; III. N_2O_4; IV. CO; V. CH_3NC

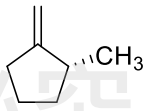
(A) I and II (B) II, III, and V (C) I, III, and V
(D) I, II, III, and V (E) I, II, and V

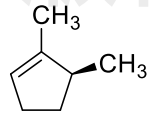
89. Identify the **major** product of the reaction below.

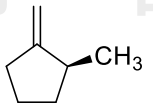


(A) 

(B) 

(C) 

(D) 

(E) 

90. If a 20.0 g sample of $CaCO_3$ is put into a 20.0 L container and heated to 800°C, what the mass percentage of the $CaCO_3$ will react to reach equilibrium? (Ca=40.08 g/mol), K_P = 1.16 at 800°C, $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$

(A) 100% (B) 76% (C) 50% (D) 24% (E) 13%

後醫-物理及化學

題號	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
答案	C	D	A	C	D	B	B	D	C	A	A	E	D	B	C	E	A	E	E	D
題號	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
答案	D	B	B	B	E	E	A	E	C	D	C	B	A	D	D	C	E	E	B	A
題號	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
答案	B	D	E	A	D	C	C	B	A	C	E	D	A	E	C	B	A	E	C	B
題號	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
答案	A	B	B	C	D	C	E	E	D	D	C	D	D	A	B	C	A	D	E	C
題號	81	82	83	84	85	86	87	88	89	90										
答案	D	E	B	E	A	C	B	A	C	A										

高雄醫學大學 114 學年度學士後醫學系招生考試試題參考答案疑義釋疑公告

科目	題號	釋疑答覆	釋疑結果
物理	7	答案無誤 $W = nRT \ln \frac{V_f}{V_i}$ (ideal gas, isothermal process).	維持原答案 (B)

高雄醫學大學 114 學年度學士後醫學系招生考試試題參考答案疑義釋疑公告

科目	題號	釋疑答覆	釋疑結果
化學	16	各選項皆正確，故本題答案無誤。	答案維持 E
	23	由於 Maillard 反應亦會導致啤酒呈現棕色，因此本題答案應修正為 A 或 B。	答案更改為 A 或 B
	65	由於 NH_4NO_3 溶解過程會產生陰陽離子，導致 ΔS_{sys} 為正值。此外，由於溶解是吸熱反應，故 ΔH 為正值，而 ΔS_{surr} 為負值。儘管 ΔS_{surr} 為負，整體的亂度仍因溶解過程而上升，因此 ΔS_{univ} 也為正值。因此，原答案正確無誤。	答案維持 D
	66	本題未明確標示反應方程式之係數，雖然平衡計算應以最小整數比進行，但選項以每 mol 為單位呈現，導致無法判定正確答案，故本題送分。	此題送分
	72	由於題幹未明確指出時間的起算點（是從反應開始計算，即 30 + 60 = 90 分鐘，或是從第一個半衰期之後起算，即 60 分鐘），因此本題的正確答案應為 A 或 D。	答案更改為 A 或 D
	73	由反應速率方程式推導可知，選項 B 所示之速率方程式亦可表示本反應的速率關係，故本題正確答案應修正為 B 或 D。	答案更改為 B 或 D
	74	由反應式推導可知，此為放熱反應，因此選項 D 亦為正確選項，故本題答案應修正為 A 或 D。	答案更改為 A 或 D
	75	由於題目已明確標示 NaF 濃度為 0.1 M，作答時依據此初始條件進行溶解度的相關計算，可合理推導出正確答案。若改以常見單位進行計算(例如 g/L，約 1.6×10^{-7} g/L)，或轉換為莫耳分率，皆無法與任何選項相符。因此，本題答案維持為 B。	答案維持 B
	76	在真實氣體系統中，壓力偏差主要來自理想氣體模型忽略氣體分子間作用力的假設錯誤。雖然選項 C 僅提及「作用力」，但其已涵蓋吸引力與排斥力的影響，因此，本題答案維持為 C。	答案維持 C
	90	本題無答案，此題送分。	此題送分

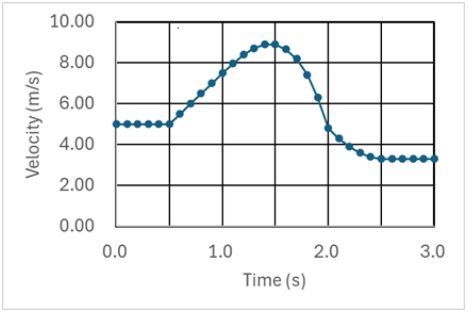
物　理

程量子(陳宗德)老師提供

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。

(C) 1. A particle moves in a track and its speed are recorded and plotted in the figure. Which statement is **correct**?



(A) It is stationary from t=0.0 to t=0.5 second.
(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.

1. 解：(C)
(A) It is *constant velocity* from t=0.0 to t=0.5 second.
(B) It has maximum *velocity* at t=1.5 seconds.
(D) The *force is zero* at t=1.5 seconds.
(E) This particle received a *variable force* against its motion during 1.0 to 2.0 seconds.

(D) 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.

2. 解：(D)

$$v = \frac{dx}{dt} = 2 \times 15\cos(15t) = 30\cos(15t) = v_m \cos(\omega t) \Rightarrow v_m = 30$$

(D) 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/s^2. Position vector $\vec{r}$ locates him relative to the rotation axis. What is the magnitude of $\vec{r}$?
(A) .5 m　(B) .6 m　(C) .4 m　(D) .6 m　(E) 2.4 m

5. 解：(D)

$$a_r = \frac{v^2}{r} \Rightarrow 1.8 = \frac{(3.7)^2}{r} \Rightarrow r = 7.6[m]$$

(B) 7. n moles of gas in a container of volume V_i at temperature T expands rapidly into an evacuated region after amembrane 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) $nRT(V_i+V_f)/V_f$

7. 解：(B)

等溫過程熱的改變 $\Delta Q = nRT\ln\left|\frac{V_f}{V_i}\right|$

(A) 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) $U(x)=-6\beta x$

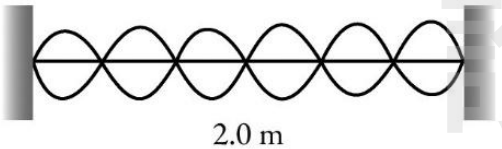
10. 解：(A)

$$U(x)-U(0)=-\int_0^x(\alpha-\beta x^3)dx=-\alpha x+\frac{\beta}{4}x^4$$

Assume that the zero of potential energy is located at $x = 0$.

$$U(x)=-\alpha x+\frac{\beta}{4}x^4$$

(B) 14. A 2.0 m string is fixed at both ends and tightened until the wave speed is 80 m/s. What is the frequency of the standing wave shown in the figure?



(A) 60 Hz (B) 120 Hz (C) 240 Hz (D) 360 Hz (E) 480 Hz

14. 解：(B)

由 $v=f\lambda$

$$80=f\times\frac{2}{3}\Rightarrow f=120[Hz]$$

(C) 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

15. 解：(C)

$$\frac{1}{n}=\frac{1.92\times10^8}{3\times10^8}\Rightarrow n=1.56$$

【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。

(C) 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) .09m (B) .15 m (C) .30 m (D) .54 m (E) 0.60 m

31. 解：(C)

$$E=\frac{1}{2}kA^2 \Rightarrow 6=\frac{1}{2}(133.3)A^2 \Rightarrow A=0.3[m]$$

(A) 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?

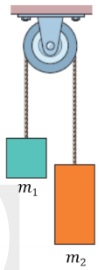
(A) 0.30 m, 1.26 s (B) 0.30 m, 0.88 s (C) 0.42 m, 0.88s
(D) 0.42 m, 1.26 s (E) 0.42 m, 5.00 s

33. 解：(A)

$$K=\frac{1}{2}(m_1+m_2)(\frac{m_1v_1}{m_1+m_2})^2=\frac{1}{2}kA^2 \Rightarrow \frac{1}{2}(2+2)(\frac{2\times 3}{2+2})^2=\frac{1}{2}(100)A^2 \Rightarrow A=0.3[m]$$

$$T=2\pi\sqrt{\frac{m_1+m_2}{k}}=2\pi\sqrt{\frac{2+2}{100}}=1.256[s]$$

(D) 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 isthe magnitude of the tension of the cord?



(A) 1.0 N (B) 2.8 N (C) 5.7 N
(D) 7.7 N (E) 20.0 N

34. 解：(D)

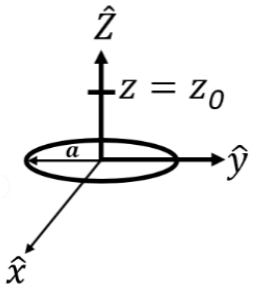
由 $\vec{F}=m\vec{a}$

$$\begin{cases}T-m_2g=-m_2a\\ T-m_1g=+m_1a\end{cases}$$

$$a=(\frac{m_2-m_1}{m_2+m_1})g=(\frac{2.8-1.3}{2.8+1.3})9.8=3.59$$

$$T-m_2g=-m_2a \Rightarrow T=m_2(g-a)=2.8\times(9.8-3.59)=17.39$$

(E) 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) $kQz_0/(z_0^2+a^2)^{3/2}$

37. 解：(E)

$$E = \frac{k_eQ}{a^2+z_0^2}\frac{z_0}{(a^2+z_0^2)^{1/2}} = \frac{k_eQz_0}{(a^2+z_0^2)^{3/2}}$$

(B) 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/m^2. A juvenile howler monkey has an acoustic output of 63 μW. 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?

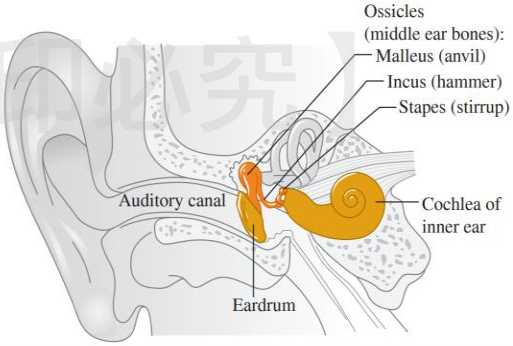
(A) 63 (B) 125 (C) 175 (D) 250 (E) 375

39. 解：(B)

$$I = \frac{Power}{A} = \frac{63\times10^{-6}}{4\times3.14\times200^2} = 1.25\times10^{-10}$$

$$\frac{I}{I_0} = \frac{1.25\times10^{-10}}{1\times10^{-12}} = 125.4$$

(B) 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.



(A) 715 Hz (B) 430 Hz (C) 860 Hz

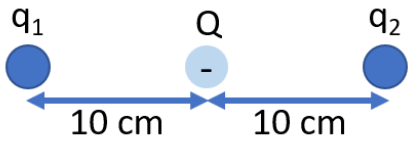
(D) 3720 Hz (E) 20580 Hz

41. 解：(B)

一端開口一端閉口

$$L = \left(\frac{2n-1}{4}\right)\frac{v}{f} \Rightarrow 0.025 = \left(\frac{2n-1}{4}\right)\frac{343}{f} \Rightarrow n = 1,\quad f = 3430[Hz]$$

(D) 42. The charge Q is −3.0 nC. How much charge q_1 is needed to bring charge q_2 into static equilibrium?



(A) −6 nC (B) nC (C) nC (D) 2 nC (E) −12 nC

42. 解：(D)

$$\frac{k_e(3)}{(0.1)^2}=\frac{k_e(q_1)}{(0.2)^2}\Rightarrow q_1=12nC$$

(D) 45. A cube of metal has an edge length of 10 cm. It has a density 3.0 g/cm^3 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) °C (B) 10°C (C) 2°C (D) 5°C (E) 0°C

45. 解：(D)

$$m=VD=(10)^3\times 3=3000[g]$$

$$\Delta U=ms\Delta T\Rightarrow 9000=3000\times 0.2\times\Delta T\Rightarrow\Delta T=15[^\circ C]$$

(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 μPa. 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) m (B) 6 m (C) 2 m (D) 0 m (E) 00 m

46. 解：(C)

$$110dB-80dB=30dB$$

$$\frac{30dB}{6dB}=5$$

$$1\rightarrow 2\rightarrow 4\rightarrow 8\rightarrow 16\rightarrow 32$$

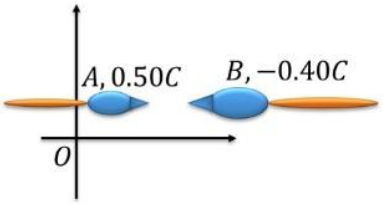
(A) 53. A square 10-turn coil with edge-length 50 cm carries a current of 2 A. It lies in the xy planewith magnetic moment in the z ($\hat{k}$) direction. It is placed in a uniform magnetic field $\vec{B}=0.3\,\hat{i}+0.4\,\hat{k}$ (T). What is the magnetic potential energy of the coil in the magnetic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

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

53. 解：(A)

$$\vec{m}=NI\vec{A}=10\times 2\times(0.5)^2\hat{k}=5\hat{k}$$
$$U=-\vec{m}\cdot\vec{B}=-5\hat{k}\cdot(0.3\hat{i}+0.4\hat{k})=-2[J]$$

(E) 54. An observer on the Earth measures the speed of spacecraft A to be 0.50c and the speed of spacecraft B to be -0.40c. 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 $u'_x=\dfrac{u_x-v}{1-\dfrac{v}{c^2}u_x}$)



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

54. 解：(E)

$$u_x'=\frac{u_x-v}{1-\dfrac{u_xv}{c^2}}=\frac{-0.4c-0.5c}{1-\dfrac{(-0.4c)(0.5c)}{c^2}}=-0.75c$$

(E) 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=1.2398×10^{-6} eV.m, the wavelength of visible light: 380 ~ 750 nm)

(A) ilver (4.26 eV) (B) opper (4.5 eV) (C) Aluminum (4.06 eV)
(D) agnesium (3.66 eV) (E) Sodium (2.36 eV)

58. 解：(E)

由光電方程式 $K=eV=\dfrac{hc}{\lambda}-e\phi$

1240/380=3.26 eV, 1240/750=1.65 eV

材料的束縛能(功函數)不能超過3.26 eV 及1.65 eV

化　學

梁傑(梁家榮)老師提供

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.

(E)

Bohr的模型是從古典物理的角度出發，但是他明確引入了量子的假設
例如：
(1)電子只能存在於特定軌道，不符合條件的軌道不存在
(2)電子在特定軌道上運動時不會輻射能量

雖然Bohr的氫原子模型的基礎是古典物理，但核心理念是量子化的能階
因此還是可以稱之為量子模型(quantum model)

19. The molecular formula of the ion is XF_3S^{3-}, 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

(E)

價電子總數：$6+3\times7+6+3=36$

中心原子X擁有的lone pair數量：$\frac{36-3\times8-1\times8}{2}=2$

屬於 AX_4E_2 型態

混成軌域為 d^2sp^3

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

(D)

	N_2	N_2^+	N_2^-
價電子總數	10	9	11
Bond order	3	2.5	2.5

BO：2>1=3

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

(A)或(B)

使用麥芽釀造啤酒的關鍵製程是烘焙，其中涉及兩個主要反應：

(1)梅納反應(Maillard reaction)：蛋白質和糖加熱後產生褐色的化合物，產生香氣

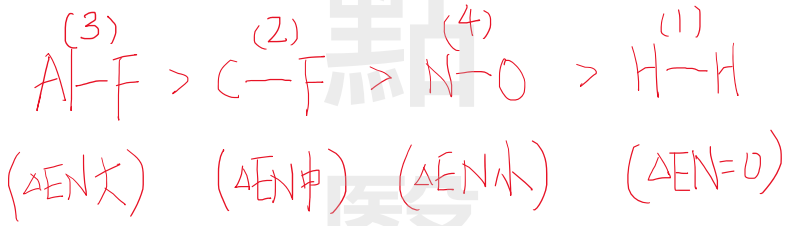
(2)焦糖化(caramelization)：糖加熱後變褐色，產生香氣

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

(B)



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

(E)

Isotope 定義：相同質子數量，但中子數量不同

↓

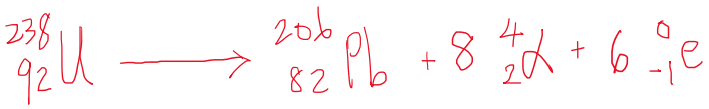
I, II都有20個質子，但中子數不同，屬於 isotope 關係

III, V都有21個質子，但中子數不同，屬於 isotope 關係

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

(D)



61. The observed osmotic pressure for a 0.10 M solution of $M(SO_4)_2$ at 27°C is 6.4 atm. Which of the following statements is **correct** regarding the expected and experimental values for *i*?

(A) $i_{expected}=3$, $i_{experimental}=2.6$ (B) $i_{expected}=4$, $i_{experimental}=3.6$
(C) $i_{expected}=3$, $i_{experimental}=3.6$ (D) $i_{expected}=4$, $i_{experimental}=2.6$
(E) $i_{expected}=2$, $i_{experimental}=2.6$

(A)

$$M(SO_4)_2 \longrightarrow M^{+4} + 2SO_4^{2-} \Rightarrow i_{expected} = 3$$

$$6.4 = i \times 0.1 \times 0.082 \times (273+27) \Rightarrow i_{experimental} = 2.6$$

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/cm^3 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)

(E)

$$7.7 = 2 \times C_M \times 0.082 \times (273+37) \Rightarrow C_M \approx 0.15\ M$$

單位換算：

$$MS\% = \frac{0.15\ mol\ NaCl \times \frac{58.5\ g\ NaCl}{1\ mol\ NaCl}}{1\ L\ soln \times \frac{1000\ mL\ soln}{1\ L\ soln} \times \frac{1\ g\ soln}{1\ mL\ soln}} \times 100\% = 0.9\ \%$$

65. In a coffee-cup calorimeter, 1.60 g NH_4NO_3 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: ΔH, ΔS_{sys}, ΔS_{surr}, and ΔS_{univ}, are positive in signs?

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

(D)

Coffee-cup calorimeter：$q_{sys} = \Delta H$

卡計水溫下降表示化學反應吸熱：$q_{sys} > 0$ 且 $\Delta H > 0$

$\Downarrow$

$\Delta S_{surr} = \frac{-q_{sys}}{T} < 0$

Dissolution of the salt：$\Delta S_{sys} > 0$ 且 $\Delta S_{univ} > 0$

$\Delta H, \Delta S_{sys}, \Delta S_{univ} > 0$

$\Delta S_{surr} < 0$

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°?

$\Delta G^\circ_f(CO_2) = -394$ kJ, $\Delta G^\circ_f(H_2O) = -299$ kJ, $\Delta G^\circ_f(CH_3OH) = -163$ kJ

(A) -1358 kJ/mol (B) -1558 kJ/mol (C) -1658 kJ/mol

(D) -1758 kJ/mol (E) -1858 kJ/mol

(送分)

$CH_3OH + \frac{3}{2}O_2 \longrightarrow CO_2 + 2H_2O$

$\Delta G^\circ_{rxn} = (-394) + 2\times(-299) + (+163) = -829 \ \frac{kJ}{mol\ CH_3OH}$

題目並未說明反應方程式為何

一般而言，當題目未說明方程式係數時，直觀上會優先以 molar combustion reaction of methanol 回答：

$CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O$

$\Delta G^\circ_{rxn} = (-394) + 2\times(-299) + (+163) = -829$

但考試當下，建議選 −829 的倍數 −1658 當作答案 (也就是燃燒 2 mol CH_3OH 的ΔG°)

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 +½ or −½.

(D) A 2*p* orbital is more penetrating than a 2*s*; i.e., it has a higher electron density near the nucleus and inside the charge cloud of a 1*s* orbital.

(E) All of these are incorrect.

(E)

(A)錯誤，該敘述違反 Pauli exclusion rule

(B)錯誤，應改為 proportional 才對

(C)錯誤，自旋量子數(m_s)的數值才必須符合 +½ 或 -½

(D)錯誤，2s 穿透能力大於 2p

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·mg^{-1}·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

(A)或(D)

(1)計算 20 mg/L 變成 5.0 mg/L 所經過的時間：

$$\frac{1}{10}=\frac{1}{20}+k\times 30\Longrightarrow k=1.67\times 10^{-3}$$

$$\frac{1}{5}=\frac{1}{20}+1.67\times 10^{-3}\times t\Longrightarrow t=90\,\text{min}$$ 答案選(D)

(2)計算 10 mg/L 變成 5.0 mg/L 所經過的時間：

$$\frac{1}{10}=\frac{1}{20}+k\times 30\Longrightarrow k=1.67\times 10^{-3}$$

$$\frac{1}{5}=\frac{1}{10}+1.67\times 10^{-3}\times t\Longrightarrow t=60\,\text{min}$$ 答案選(A)

由於題目敘述上稍有瑕疵，建議本題(A)(D)皆給分

(出題老師同意題幹並未明確指明反應時間的起算點，釋疑後同意(A)(D)皆給分)

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= $k_1\,[NO_2][F_2]$ (E) None of the above.

(B)或(D)

由於 first step 是 RDS

其速率式可直接用反應機構的第一步表示：$\text{Rate}=k_1[NO_2]^1[F_2]^1$

題目已提供全反應的速率常數為 k，因此反應速率亦可表示為：$\text{Rate}=k[NO_2]^1[F_2]^1$

因此(B)或(D)皆給分

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

where ΔG^o = -31.3 kJ/mol of N_2 consumed at 25°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

(A)或(D)

依照題目條件，此時反應的起始物和產物皆處於標準狀態

可由 $\Delta G° < 0$ 判斷反應要向右，(A)選項正確

雖然由題幹無法知道此反應放熱，但由於Haber process是很有名的放熱反應

加熱會使放熱反應的平衡向左，因此(D)選項也是正確答案之一

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.

(C)

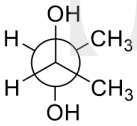
Kinetic molecular theory假設氣體分子間無作用力

但由於真實氣體間有作用力，在 van der Waals equation 中需要對壓力作修正

82. What is the structural relationship of the following two compounds?

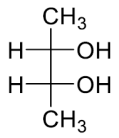
(A) same compound (B) enantiomers (C) *cis-trans* isomers
(D) structural isomers (E) diastereomers

(E)



結構上找不到內部對映面或反轉中心

屬於 chiral 分子



結構具有內部對映面

屬於 achiral 分子

兩者原子間連接順序相同

但基團之間的空間擺向不同

屬於沒有鏡像關係的立體異構物

稱為非鏡像異構物(diastereomer)

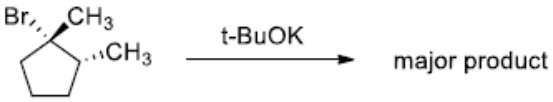
84. Which of the following becomes more soluble in water upon addition of NaOH?

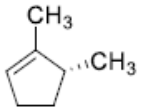
(A) an amine (B) a carboxylic acid (C) a phenol
(D) an alkane (E) two of these

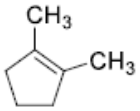
(E)

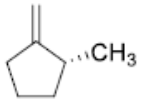
(B)和(C)都可以和 NaOH 進行酸鹼反應轉成相對應的 salt，增加對水溶解度

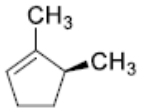
89. Identify the **major** product of the reaction below.

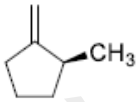


(A) 

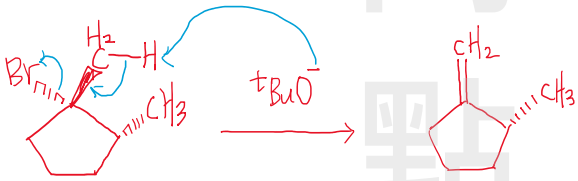
(B) 

(C) 

(C) (D) 

(E) 

此反應為 E2 反應，由於使用的是 bulk base，傾向得到少取代烯



90. If a 20.0 g sample of $CaCO_3$ is put into a 20.0 L container and heated to 800°C, what the mass percentage of the $CaCO_3$ will react to reach equilibrium? (Ca=40.08 g/mol), K_P = 1.16 at 800°C,

$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$

送分 (A) 100% (B) 76% (C) 50% (D) 24% (E) 13%

$1.16 \times 20 = n_{CO_2} \times 0.082 \times (273+800) \Rightarrow n_{CO_2} = 0.26\ mol$

要使反應達平衡，CO_2 的分壓須達到 1.16 atm

要達到1.16 atm的CO_2分壓所需的 CO_2 莫耳數為 0.26 mol

由於起始 $CaCO_3$ 只有 0.2 mol，就算完全分解也無法達到平衡

題幹問「達平衡時」$CaCO_3$的分解百分率

在根本無法達平衡的情況下，本題無正確答案可選