注意：考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。

國立清華大學 113 學年度學士後醫學系單招試題

系所班組別：學士後醫學系
自然科學組

科目代碼：0103

考試科目：化學與物理

—作答注意事項—

1. 請核對答案卡上之准考證號、科目名稱是否正確。
2. 作答中如有發現試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
4. 其他應考規則、違規處理及扣分方式，請自行詳閱簡章附錄上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 113 學年度學士後醫學系單獨招生試題

考試科目：化學與物理

Choose one best answer for the following questions

【單選題】每題 2.5 分，共計 150 分，答錯一題倒扣 0.625 分，未作答，不給分亦不扣分。1~30 題為化學，31~60 題為物理。

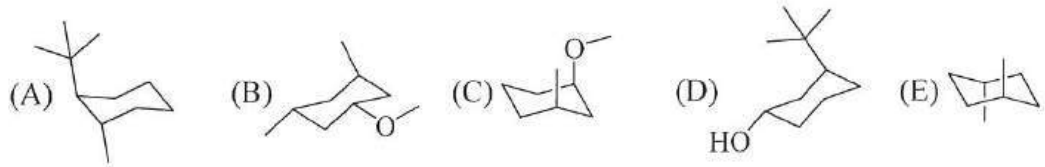
1. A mixture of $C_2H_6(g)$ and $C_3H_8(g)$ in a closed rigid container has a total pressure of 1.0 atm. Just enough $O_2(g)$ is added to the mixture to bring about its complete combustion to $CO_2(g)$ and $H_2O(g)$. After the combustion, the total pressure in the container is 6.3 atm. Assuming constant temperature and volume, find the mole fraction of $C_3H_8(g)$ in the original mixture.
   (A) 0.25　(B) 0.35　(C) 0.50　(D) 0.65　(E) 0.75

2. Stretch a rubber band while holding it gently to your lips. Then, let it relax while still in contact with your lips. Which of the following statements about the above process are correct?
   (I) The temperature of the rubber band increases on stretching.
   (II) The stretching is an endothermic process.
   (III) The intermolecular forces within the rubber band increase on stretching.
   (IV) ΔG is negative for stretching the rubber band.
   (V) ΔS is negative for stretching the rubber band.
   (A) I, II　(B) II, IV　(C) III, IV　(D) I, III, V　(E) I, IV, V

3. When the compound with a molecular formula of $C_6H_{14}O$ is oxidized, a ketone is produced. How many possible structures are for $C_6H_{14}O$ in this reaction?
   (A) 4　(B) 5　(C) 6　(D) 7　(E) 8

4. At 25 °C, what is the approximate pH of a 0.5 M ammonium nitrite (NH_4NO_2) solution? ($K_a = 5.6 \times 10^{-10}$ for NH_4^+, 4.0×10^{-4} for HNO_2; log2 = 0.301, log7 = 0.845)
   (A) 4.70　(B) 5.40　(C) 6.30　(D) 7.50　(E) 8.60

5. Which of the following show the more stable chair conformers (from two possible chair conformers) of the cyclohexane scaffolds?



6. Given the following standard reduction potentials at 25 °C:

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s) \quad E° = 0.34\ V$$
$$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s) \quad E° = -0.76\ V$$

In a galvanic cell, the copper compartment contains a copper electrode and $[Cu^{2+}] = 1.00$ M. The zinc compartment contains a zinc electrode and Zn^{2+} at an unknown concentration. The compartment containing the zinc (1.00 L of solution) was titrated with 0.600 M H_2EDTA^{2-}, resulting in the reaction:

$$H_2EDTA^{2-} + Zn^{2+} \rightleftharpoons Zn(EDTA)^{2-} + 2\ H^+$$

The potential of the cell was monitored to determine the stoichiometric point for the process, which occurred when 400.0 mL of H_2EDTA^{2-} solution was added. What is E_{cell} at the halfway point of titration?

(A) 1.04 V　(B) 1.07 V　(C) 1.10 V　(D) 1.13 V　(E) 1.16 V

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

(A) $2\ NO(g) + 2\ CO(g) \rightarrow N_2(g) + 2\ CO_2(g)$ is spontaneous at room temperature, then the reaction has $\Delta H > 0$.

(B) The reaction $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$ can proceed spontaneously at room temperature, so the ΔH of the reaction is < 0.

(C) For the reaction $MgCl_2(1) \rightarrow Mg(l) + Cl_2(g)$ to proceed at a certain temperature, it has $\Delta H > 0$ and $\Delta S > 0$.

(D) The reaction $C(s) + CO_2(g) \rightarrow 2CO(g)$ cannot proceed spontaneously at room temperature, then the reaction has $\Delta H > 0$.

(E) After the coating of copper-plated iron products is broken, the iron products are more likely to corrode than before the damage.

8. It is known that 3.6 g of simple carbon is burned in 6.4 g of O_2 until the reactants are exhausted, giving off X kJ of heat. The heat of complete combustion of simple carbon is Y kJ·mol^{-1}. What is the heat of reaction ΔH for the reaction of 1 mole of simple carbon with O_2 to form CO?

(A) $-Y$ kJ·mol^{-1}　(B) $-(10X - Y)$ kJ·mol^{-1}　(C) $-(5X - 0.5Y)$ kJ·mol^{-1}

(D) $+(10X - Y)$ kJ·mol^{-1}　(E) $+(5X - 0.5Y)$ kJ·mol^{-1}

9. If 100 mL of 0.4 M $Ba(OH)_2$ solution is added to a sufficient amount of H_2SO_4 solution, the amount of heat released is 5.12 kJ. If 100 mL of 0.4 M HCl solution is added to a sufficient amount of $Ba(OH)_2$ solution, the amount of heat released is 2.2 kJ. Which of the following is the thermochemical equation for the reaction between an Na_2SO_4 solution and a $BaCl_2$ solution?

(A) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ $\Delta H = -0.72\ kJ \cdot mol^{-1}$

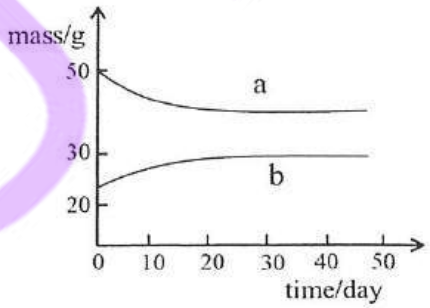
(B) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ $\Delta H = -2.92\ kJ \cdot mol^{-1}$

(C) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ $\Delta H = -18\ kJ \cdot mol^{-1}$

(D) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ $\Delta H = -20.92\ kJ \cdot mol^{-1}$

(E) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ $\Delta H = -21.64\ kJ \cdot mol^{-1}$

10. Concentrated sulfuric acid and 2 M of dilute sulfuric acid are placed open in the experiment. The relationship between their masses and the number of days in which they are placed is shown in the figure on the right. Which of the following process pairs is responsible for the change in the curves of a and b?



	a	b
(A)	sublimation	condensation
(B)	evaporation	water absorption
(C)	evaporation	deliquescence
(D)	condensation	water absorption
(E)	condensation	deliquescence

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

(A) Na_2S, NaCl, Na_2SO_4

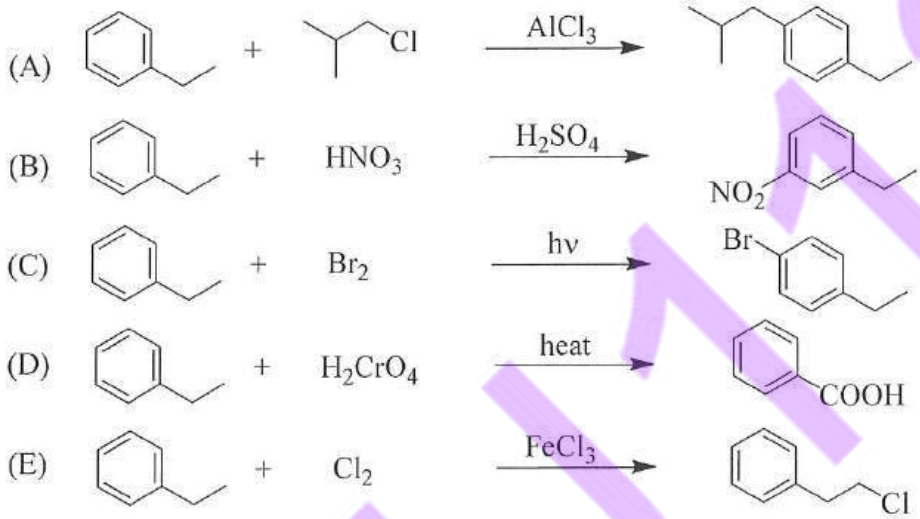
(B) Na_2SO_4, NaCl, Na_2S

(C) Na_2SO_4, Na_2S, NaCl

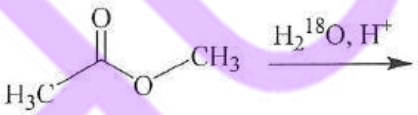
(D) NaCl, Na_2S, Na_2SO_4

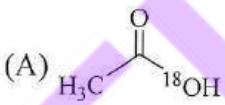
(E) NaCl, Na_2SO_4, Na_2S

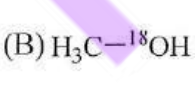
12. Which of the following reactions produces the correct major product?

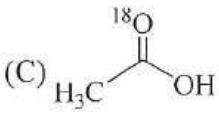


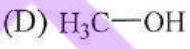
13. Consider the following reaction, which product is *least likely* to be observed?

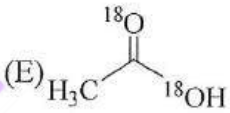




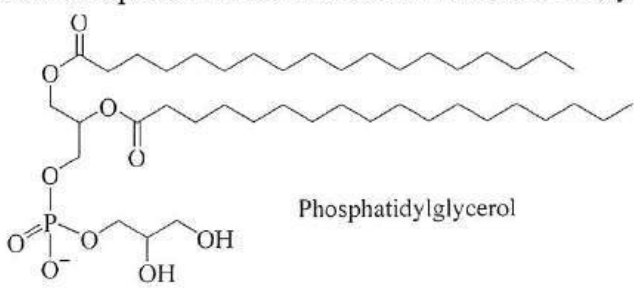








14. Phosphatidylglycerol is an important component in bacterial membrane and many anti-microbial peptides have been found to kill bacteria by the interaction with the membrane under physiological conditions. Which of the following residues in the anti-microbial peptides is the most likely to bind to a membrane of Phosphatidylglycerol?



Phosphatidylglycerol

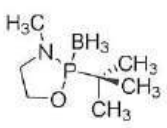
(A) Arginine　(B) Glycine　(C) Glutamic acid　(D) Serine　(E) Cysteine

15. Which of the following comparisons of the intermolecular dispersion force is *incorrect*?

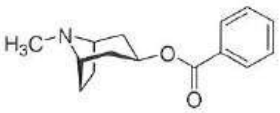
(A) $C_3H_7OH > C_2H_5OH$　　(B) $CCl_4 > SiCl_4$　　(C) $Br_2 > O_2$

(D) $Ar > Ne$　　(E) $CH_3CH_2CH_2Cl > (CH_3)_2CHCl$

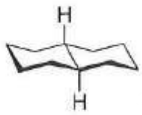
16. Which of the following is a chiral compound?



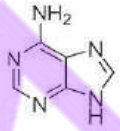
I



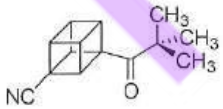
II



III



IV



V

(A) I　　(B) II　　(C) III　　(D) IV　　(E) V

17. The osmotic pressure of a 0.010 M aqueous solution of potassium sulfate was measured to be 0.660 atm at 25 °C. What is the van't Hoff factor (i) for this solution? (gas constant R = 0.082 atm·L/mol·K)

(A) 0.37　　(B) 0.90　　(C) 0.98　　(D) 2.70　　(E) 2.95

18. Which of the following compound names conforms to IUPAC nomenclature?

(A) 1-methyl-2-bromobutane

(B) 2,2-dibromo-3-chloropropane

(C) 2-ethyl-3-chloropentane

(D) 3-methyl-3-fluoropentane

(E) 1,2-dichloro-3-nitrohexane

19. Which of the following statements for the unsaturated hydrocarbons is correct?

(A) Benzene is more reactive than ethene toward hydrogenation reaction.

(B) Combustion of acetylene releases more heat than benzene of the same weight.

(C) Ethene is more reactive than benzene toward electrophilic substitution reaction.

(D) Both benzene and acetylene have planar molecular geometry.

(E) Addition of chlorine can be performed on acetylene, benzene and ethene under mild conditions.

20. The dissolution of a strong electrolyte of type A_mB_n in water (which can be regarded as a special chemical reaction) is expressed as $A_mB_n = A^{n+}(aq) + B^{m-}(aq)$, with enthalpy and entropy changes of ΔH and ΔS, respectively. Which of the following statements best describesthe dissolution of strong electrolytes of type A_mB_n of different compositions?

(A) Both ΔH and ΔS are positive.

(B) Both ΔH and ΔS are negative.

(C) ΔH ispositive, and ΔS is negative.

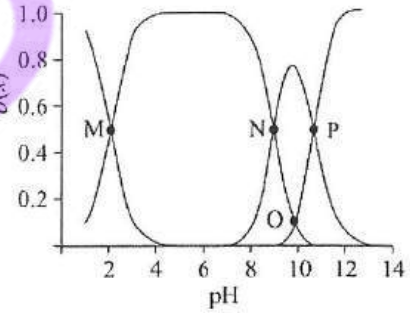
(D) ΔH may be positive or negative, and ΔS is positive.

(E) Both ΔH and ΔS may be positive or negative.

21. Lysine $H_3N^+(CH_2)_4CH(NH_2)COO^-$ (denoted by HR) is an essential amino acid, and its hydrochloride salt ($[H_3R]Cl_2$) exists in aqueous solution in the following equilibrium:

$$H_3R^{2+} \underset{}{\overset{K_1}{\rightleftharpoons}} H_2R^+ \overset{K_2}{\rightleftharpoons} HR \overset{K_3}{\rightleftharpoons} R^-$$

When an NaOH solution is added to a certain concentration of $[H_3R]Cl_2$ solution, the distribution coefficients $\delta(x)$ of H_3R^{2+}, H_2R^+, HR, and R^- vary with pH as shown on the right.



Given that $\delta(x) = \frac{[x]}{[H_3R^{2+}]+[H_2R^+]+[HR]+[R^-]}$, which of the following statements is correct?

(A) $\frac{K_2}{K_1} > \frac{K_3}{K_2}$

(B) At M, $[Cl^-] + [OH^-] + [R^-] = 2[H_2R^+] + [Na^+] + [H^+]$

(C) $[H_2R^+]$, [HR], and $[R^-]$ cannot be in the solution at the same time.

(D) At O, $pH = \frac{-\log K_2 - \log K_3}{2}$

(E) At P, $[Cl^-] > [Na^+] > [OH^-] > [H^+]$

22. The use of N_2O_5 as a nitrifying agent is a new type of green nitrification technology, which has been widely used in industries such as energy-containing materials and pharmaceuticals. For the reaction $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$, the following reaction sequence was proposed,

Step 1: $N_2O_5 \rightleftharpoons NO_2 + NO_3$　fast equilibrium

Step 2: $NO_2 + NO_3 \rightarrow NO + NO_2 + O_2$　slow

Step 3: $NO + NO_3 \rightarrow 2NO_2$　fast

where it can be approximated that the second step does not affect the equilibrium of the first step. Which of the following statements is correct?

(A) the rate of the reverse reaction of the first step<the rate of the reaction of the second step

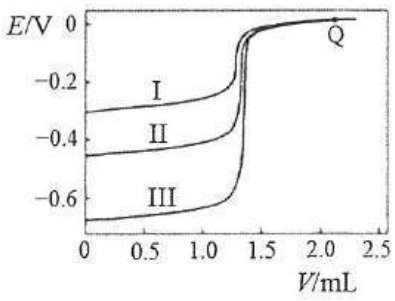
(B) The only intermediate product of the reaction is NO_3.

(C) The collision of NO_2 with NO_3 in the second step is only partially effective.

(D) The activation energy of the reaction in the third step is higher than the other two.

(E) The rate law of this reaction is rate = $k[NO_2][NO_3]$.

23. You titrated 15 mL of 0.01 M NaCl, NaBr, and NaI solutions with 0.1 M $AgNO_3$ solution, respectively, and used an Ag_2S electrode to monitor the change in Ag^+ concentration during the titration. The measured Ag_2S electrode potential (E) versus the volume (V)of $AgNO_3$ solution consumed is shown on the right. It is known that the electromotive force of Ag_2S electrode increases with the increase of $[Ag^+]$, and the produced silver halide by titration exists as a colloid. Which of the following statements is correct?



(A) The titration of NaCl solution is curve I.

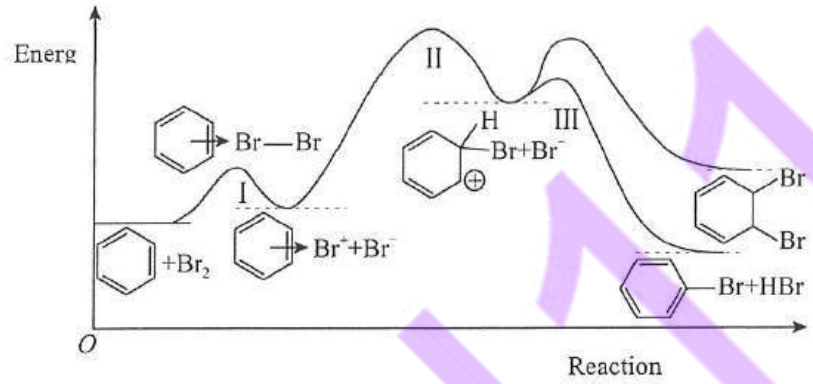
(B) Q is the titration end point.

(C) The $[Ag^+]$ at Q is 0.1 M.

(D) From the figure, it can be seen that the silver halide colloid particles mainly adsorb Ag^+.

(E) This method can be used to determine the concentration of halide ions in solution.

24. The catalyzed reaction of benzene with Br_2 is shown in the following figure. Which of the following statements is correct about the sequence of reactions?



(A) Reactions of benzene and Br_2 are exothermic.

(B) From the reaction rate point of view, the catalyzed reaction of benzene with Br_2 is mainly a substitution reaction due to the lower activation energy of the reaction.

(C) Both bromobenzene and *o*-dibromobenzene are produced from the catalyzed reaction of benzene and Br_2.

(D) The rate-determining step in the catalyzed reaction of benzene with $Br_2$is accompanied by the breaking and formation of polar bonds.

(E) Heating the reaction not only speeds it up, but increases the equilibrium conversion of the substitution reaction.

25. Ca^{2+}, Mg^{2+}, and $SO_4^{2-}$are removed when purifying crude salt (NaCl) in the laboratory. Which of the following reagents are needed in addition to $BaCl_2$?

(A) Na_2CO_3, NaOH, and HCl

(B) Na_2CO_3, HCl, and KOH

(C) K_2CO_3, HNO_3, and NaOH

(D) Na_2CO_3, NaOH, and HNO_3

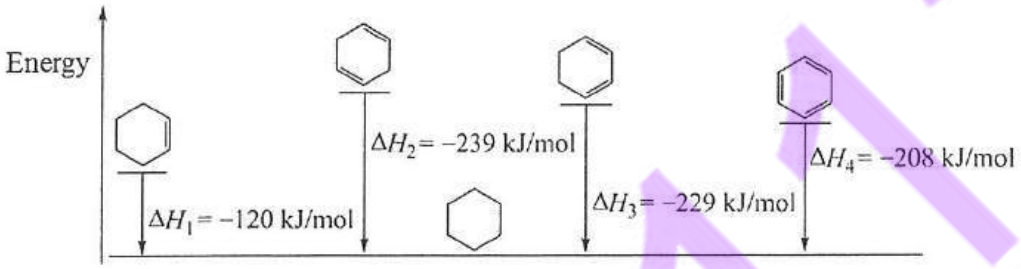
(E) K_2CO_3, HCl, and KOH

26. At 25 °C, 10 volumes of a strong acid solution of pH = m is mixed with 1 volume of a strong alkali solution of pH = n and the resulting solution is neutral. What is the relationship between the pH of the strong acid and the pH of the strong alkali before mixing?

(A) m + n = 15　(B) m + n = 13　(C) m + n = 11

(D) m + n = 10　(E) m + n = 9

27. The energy changes for the hydrogenation of 1 mole of cyclohexene, cyclohexadienes, and benzene to produce 1 mole of cyclohexane are as follows.



Which of the following statements is *incorrect*?

(A) $2\Delta H_1 \approx \Delta H_2$, so the amount of heat released from hydrogenation of carbon-carbon double bonds is proportional to the number of carbon-carbon double bonds in the molecule.

(B) $\Delta H_2 < \Delta H_3$, so the interaction between two carbon-carbon double bonds alternates between single and double bonds, contributing to the stability of the substance.

(C) $3\Delta H_1 < \Delta H_4$，so there are not three completely independent carbon-carbon double bonds in the benzene molecule.

(D) $\Delta H_3 - \Delta H_1 < 0$，$\Delta H_4 - \Delta H_3 > 0$，so the benzene molecule has a special stabilizing property.

(E) The C–H bond energy is greater than the average of the C–C π bond and H–H bond energy.

28. The related properties of molecules, ions, and compounds are compared in the following:

(I) Bond angle: $CS_2 > SO_2 > SCl_2$

(II) Polarity: $SO_3 > IF_3$

(III) Melting point: $MgO > NaCl > LiF$

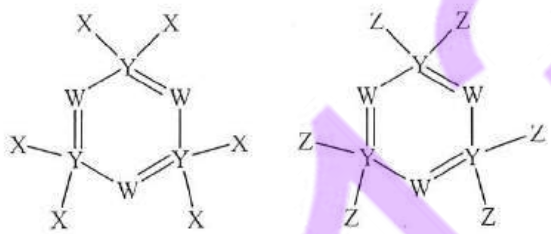
(IV) Boiling point: $ICl > Br_2 > GeH_4$

(V) Bond length: $O_2^+ > O_2 > O_2^{2-}$

Which of the comparisons are correct?

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

29. The two compounds shown on the right are used to synthesize flame retardant materials and biomaterials. The atomic numbers of the elements W, X, Y and Z are known to be W < X < Y < Z < 20, X and Z are in the same group, and the atomic number of Y is three times the number of valence electrons of W.



Which of the following statements is correct?

(A) The highest oxidation state of both X and Z is +7.

(B) Both HX and HZ are strong acids in water, and their electron dot structures can be expressed as H:$\ddot{\underset{\cdot\cdot}{X}}$: and H:$\ddot{\underset{\cdot\cdot}{Z}}$:.

(C) Z, W, and hydrogen form a covalent compound, which is soluble in water.

(D) X and Z form compounds XZ, XZ_3, XZ_5 and XZ_7.

(E) Of these four elements, Y has the largest atomic radius, while X has the smallest.

30. The elements X, Y and Z can be combined to form the compound XYZ_3; the sum of the atomic numbers of X, Y and Z is 26. Y and Z are in the same period. Which of the following assumptions is correct?

(A) XYZ_3 is a water-soluble acid and X and Y form the covalent compound XY.

(B) XYZ_3 is a salt, slightly soluble in water, and X and Z form the ionic compound XZ.

(C) XYZ_3 is a water-soluble salt, and Y and Z can form the ionic compound YZ.

(D) XYZ_3 is an ionic compound, and Y and Z can form ionic compound YZ_2.

(E) XYZ_3 is a water-soluble salt, and X and Z can form an acidic compound X_2Z.

31. In a Carnot engine, what is the working substance?

(A) the air　(B) an ideal gas　(C) the gasoline

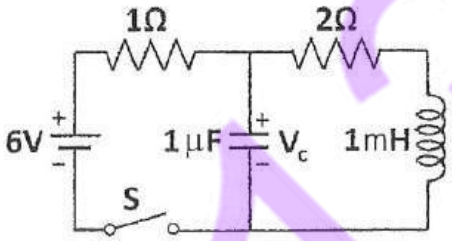
(D) the water vapor (steam)　(E) None of these.

32. What is the approximate heat capacity ratio, $\gamma = C_p/C_v$, for methane under NTP conditions (298 K and 1 atm)?

(A) 1.64 ~ 1.69　(B) 1.36 ~ 1.41　(C) 1.29 ~ 1.34

(D) 1.20 ~ 1.27　(E) None of these.

33. The switch S in the circuit on the right is closed at $t = 0$. What is the voltage (V_c) across the capacitor after a very long time (*i.e.*, much larger than the time constant t) when both the capacitor and the inductor are in a steady state?



(A) 6V　(B) 4V　(C) 3V　(D) 2V　(E) 0V

34. What is the key factor of the Sun that directly determines our human (and many animals) adaptation and sensitivity to its visible light?

(A) its mass　(B) its radius　(C) its total radiation

(D) its surface temperature　(E) geomagnetic storms and solar flares

35. Which of the following phenomena is *not* due to the tunneling effect?

(A) field emission microscope

(B) ammonia inversion

(C) nuclear alpha decay

(D) magnetic resonance imaging

(E) stellar nucleosynthesis

36. Which of the following functions is *not* a solution to the one-dimensional wave equation?

(A) $y(x,t) = y_m \sin(kx - \omega t + \phi)$

(B) $y(x,t) = 2y_m \sin\left(kx + \frac{\phi}{2}\right)\cos\left(\omega t - \frac{\phi}{2}\right)$

(C) $y(x,t) = \frac{-5}{(3x + 6t - 4)^2 + 2}$

(D) $y(x,t) = Ae^{-(kx+\omega t+\phi)^2}$

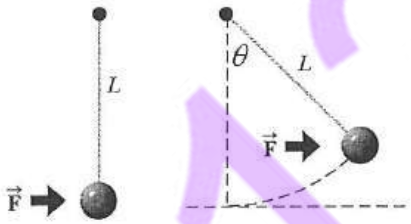
(E) All the above wave-function forms satisfy the wave equation.

37. Which of the following physical quantities has its unit as newton (N)?

(A) the compressive stress　(B) the hydraulic pressure　(C) the surface tension

(D) the electromotive force (emf)　(E) None of these.

38. As shown on the right, a ball of mass m is attached to a pivot fixed in place by means of a string of length L. The ball is in a state of rest. A constant force F is applied horizontally to cause the ball to swing upwards. What is the kinetic energy of the ball when the string makes an angle of θ with the vertical line?



(A) $FL(1-\cos\theta)$　(B) $FL\sin\theta$　(C) $FL\tan\theta + mgL\sin\theta$

(D) $FL\sin\theta + mgL(\cos\theta - 1)$　(E) 0

39. Which of the following statements about gravity and planet motion is correct?

(A) In a non-uniform gravitational field, the center of gravity of an object is still located at the same position as its center of mass.

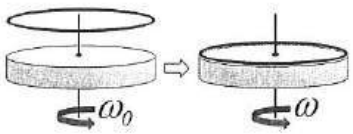
(B) The planet Mercury has smaller orbiting velocity than that of planet Jupiter

(C) On earth, the escape velocities of hydrogen and helium atoms are the same.

(D) If Newton's Law of gravity becomes $F = Gm_1m_2/r^{2.1}$, Kepler's second law (dA/dt = constant) is still correct.

(E) As Halley's Comet moves away from the sun, its velocity becomes greater and greater.

40. A uniform disk of mass m and radius R is rotating about its symmetric axis at an angular velocity ω_0. A ring of the same mass m and radius R originally at rest suddenly drops on the disk. Due to friction, the disk and the ring finally rotate together at a constant anular velocity ω. What is the kinetic energy loss during this process?



(A) $\frac{1}{2}mR^2\omega_0^2$　(B) $\frac{1}{4}mR^2\omega_0^2$　(C) $\frac{1}{6}mR^2\omega_0^2$　(D) $\frac{1}{8}mR^2\omega_0^2$

(E) Energy is conserved, so there is no energy loss.

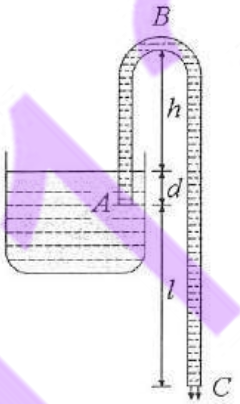
41. Two pulses traveling on the same string are described by

$$y_1 = \frac{5}{(3x-4t)^2+2} \qquad y_2 = \frac{-5}{(3x+4t-6)^2+2}$$

Where is he location of the node where these two pulses always cancel?

(A) 3/4　(B) 1　(C) −4/3　(D) 4/3　(E) 2

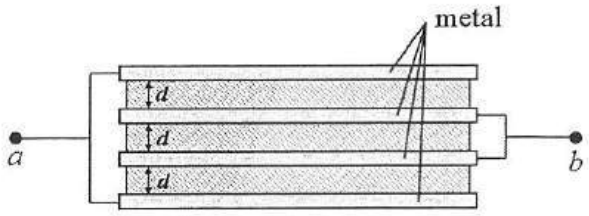
42. A siphon tube is used to transport liquid from a higher location to a lower location without electric pumps. The tube sinks into the liquid by a length d. The highest point of the tube, point B is at a distance h from the surface of the liquid. The outlet of the tube, point C is at a distance $d + l$ from the surface of the liquid. The density of the liquid is ρ. The atmosphere pressure is P_0. The gravitational field is g. What is the velocity of the liquid coming out at point C?



(A) $\sqrt{2gh}$　(B) $\sqrt{2g(d+l)}$　(C) $\sqrt{2g(h+d+l)}$
(D) $\sqrt{2gl}$　(E) $\sqrt{2g(h+d)}$

43. Which of the following statements about modern physics is *incorrect*?
(A) Photons are their own anti-particles.
(B) The neutron obeys the Pauli's exclusion principle.
(C) At the same temperature, the electron has a longer de Broglie wavelength than the proton.
(D) In Compton scattering, the wavelength of the scattered photon is longer than the wavelength of the incident photon.
(E) Special relativity sets an upper limit for the velocity of a particle. Therefore, there is also an upper limit for the energy that a particle can have.

44. Four identical large thin metal plates are separated by three layers of dielectric material with dielectric constant κ. Each metal plate has area A and the thickness of each dielectric layer is d. The outer two plates are connected to point a, and the inner two plates are connected to point b. What is the equivalent capacitance between point a and b? (The capacitance of two large metal plate separated by d is $\frac{\epsilon_0 A}{d}$)

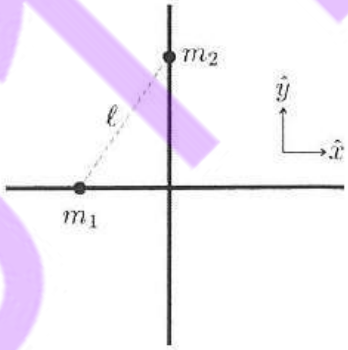


(A) $\frac{\kappa\epsilon_0 A}{d}$　(B) $\frac{2\kappa\epsilon_0 A}{d}$　(C) $\frac{\kappa\epsilon_0 A}{2d}$　(D) $\frac{4\kappa\epsilon_0 A}{d}$　(E) $\frac{\kappa\epsilon_0 A}{4d}$

45. A uniformly charged insulating rod is bent into the shape of a semicircle as shown on the right. The rod has a total charge Q and the radius of the semicircle is R. What is the magnitude of the electric field at O, the center of the semicircle?

(A) $\frac{Q}{2\epsilon_0\pi^2R^2}$　(B) $\frac{Q}{4\epsilon_0\pi R^2}$　(C) $\frac{Q}{\epsilon_0\pi R^2}$　(D) $\frac{Q}{4\epsilon_0R^2}$　(E) $\frac{Q}{2\epsilon_0R^2}$

46. Two particles are confined to move along frictionless tracks as depicted in the figure on the right, where m_1 can only move along the horizontal track, and m_2 can only move along the vertical track. The two masses are connected by a rigid, massless rod of length ℓ. Assume both masses are the same and are subject to gravity in the $-\hat{y}$ direction. With their initial positions indicated in the figure, which of the following statements is true?



(A) m_1 can never reach the right-hand side of the vertical track regardless of their initial velocities.

(B) m_2 can never reach a higher position than its initial position regardless of their initial velocities.

(C) If both masses are initially at rest, m_2 can never reach a higher position than its initial position.

(D) m_1 can reach the right-hand side of the vertical track only if it has an initial velocity in the $+\hat{x}$ direction.

(E) None of the above.

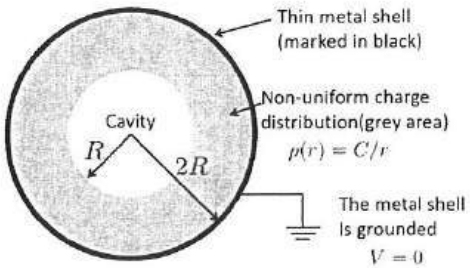
47. A typical small flashlight contains two batteries, each with an emf of 1.5 V, connected in series with a bulb having resistance 17 ohms. The internal resistance is negligible. The batteries last for 5.0 h. Which of the following values most closely approximates the total energy delivered to the bulb?

(A) 9000 J　(B) 7000 J　(C) 5000 J　(D) 2000 J　(E) 600 J

48. For the speed of sound, we know that the speed of sound is underestimated if an isothermal thermodynamic process is considered rather than an adiabatic process. Which of the following is true?
(A) The bulk modulus of air during an adiabatic process is greater than the bulk modulus during an isothermal process.
(B) The bulk modulus of air during an adiabatic process is less than the bulk modulus during an isothermal process.
(C) The speed of sound is independent of the bulk modulus of air.
(D) The speed of sound increases with decreasing temperature.
(E) None of the above

49. An ideal gas undergoes an irreversible process from its initial state (P_i, V_i, T_i) to its final state (P_f, V_f, T_f). Which of the following statements is true?
(A) The change in the entropy of the gas is not well defined since it is an irreversible process.
(B) The change in the entropy is well defined and will increase when $V_f > V_i$.
(C) The change in the entropy is well defined and will increase when $P_f > P_i$.
(D) The change in the entropy is well defined and will increase when $T_f > T_i$.
(E) None of the above.

50. Charges are distributed non-uniformly in between the space of two infinitely long concentric cylinders of radius R and 2R, respectively, as shown in the figure on the right. There is no charge in the region r < R and r > 2R. In the region R < r < 2R, the charge density only depends on the radial distance ρ(r) = C/r, and C > 0. In addition, a metal shell is attached to the surface of the outer cylinder, and it is grounded with the electric potential set to 0. Which of the following statements is true?



(A) The electric field in the region R < r < 2R decays with r.
(B) The electric potential in the region R < r < 2R decays linearly with r.
(C) There is a positive surface charge residing on the inner surface of the outer cylinder.
(D) The electric potential in the cavity region is 0.
(E) None of the above.

51. For a particle in a three-dimensional cubic box with infinite potential walls, its energy level dependd on three quantum numbers. Let us denote these three quantum numbers by (n, l, m). Which of the following statements is true?
(A) The energy of the particle only increases with the quantum number n.
(B) The ground state energy is zero.
(C) These quantum numbers have specified allowed ranges: $n \geq 1$, $0 \leq l \leq n-1$, $-l \leq m \leq l$.
(D) The probability density function is uniform throughout the box.
(E) None of the above is true.

52. An RLC circuit composed of a resistor, inductor, and capacitor connected in series with an AC voltage source. Which of the following statements is true?
(A) The current always lags the voltage by 90° due to the inductor.
(B) The current always lags the voltage by 90° due to the capacitor.
(C) The current always lags the voltage by 90° due to the resistor.
(D) The lag between the current and the voltage depends on the frequency of the AC voltage source.
(E) None of the above is true.

53. According to observers on the Earth frame, a planet is 30 light-years away from Earth. If we plan to send a spaceship traveling at a constant speed of 0.6 c to explore the alien planet, which of the following statements is false?
(A) The time the astronaut on board will take to reach the alien plant is less than 50 years.
(B) The distance the astronaut on board travels to reach the alien plant is less than 30 light years.
(C) For a clock that is stationary to the Earth frame, recording a 1-second duration by the Earth's observer, the astronaut observes a longer duration than 1 second.
(D) For a clock that is stationary to the spaceship frame, recording a 1-second duration by the astronaut, the Earth's observer observes a longer duration than 1 second.
(E) None of the above is false.

54. Find the binding energy of carbon-12 based on the following data:

mass of a carbon atom = 12.000000 u

mass of a proton = 1.007825 u

mass of a neutron = 1.008665 u

1 u = 1.66×10^{-27} kg

(A) 0.511 *MeV* (B)14.8 *MeV* (C) 46.2 *MeV* (D) 92.3 *MeV* (E) 1211.3 *MeV*

55. A soccer ball has a mass of 0.4 kg. Initially, it moves to the left at a speed of 20 m/s, but is then kicked with a speed of 30 m/s, upwards and to the right 45°. Assuming that the collision time Δt = 0.01 s, which of the following values most closely approximates the magnitude of the average kick force (in Newtons)?

(A)5 (B)180 (C)500 (D)1800 (E)5000

56. A geosynchronous satellite is one that stays above the same point on the Earth's equator. Which of the following values is closest to the satellite's distance (km) from the Earth's center? ($G = 6.67 \times 10^{-11}\ N \cdot \frac{m^2}{kg^2}$; $m_E = 6.0 \times 10^{24}$ kg)

(A) 3×10^3 (B) 7×10^3 (C) 1×10^4 (D) 4×10^4 (E) 1×10^5

57. Two spring-block systems are placed in a viscous environment independently. The viscous forces experienced by the blocks is approximately linearly proportional to the speed of blocks. Due to the damping effect, both spring-block systems exhibit underdamped oscillating behavior. The shape of blocks of the two systems is the same, but the mass and spring constant of the 1st and the 2nd system are (1 kg, 1 N/m) and (1.2 kg, 0.9 N/m), respectively. Initially, both blocks are at rest and are released 5 cm away from their equilibrium positions. Which of the following statements is true?

(A) It takes a longer time for the block in the 2nd system to finally come to rest.

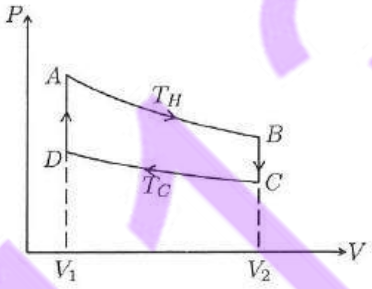
(B) It is not possible for these two systems to both exhibit underdamped behavior.

(C) Both blocks move towards the equilibrium position and then stop at the equilibrium position.

(D) In the very beginning, the oscillation frequency is larger for the 1st system.

(E) In the very beginning, the oscillation frequency is larger for the 2nd system.

58. The Stirling engine cycle ($A \rightarrow B \rightarrow C \rightarrow D$) consists of 4 parts as shown in the figure on the right. $A \rightarrow B$ and $C \rightarrow D$ are isothermal expansion and compression processes, respectively, while $B \rightarrow C$ and $D \rightarrow A$ are isochoric (fixed volume) processes. Assume that the Suppose a Stirling engine contains 1 mole of an ideal gas. Which of the following statements is *incorrect*?

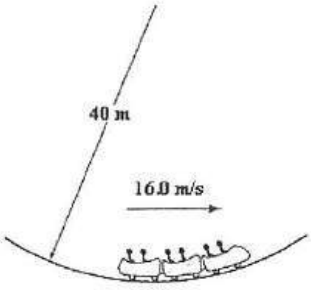


(A) The heat absorbed by the gas in one cycle is more than the heat released.
(B) The change of entropy of the gas after one cycle is greater than zero.
(C) The internal energy of the gas remains a constant during the segment $A \rightarrow B$.
(D) The internal energy of the gas drops during the segment $B \rightarrow C$.
(E) When the cycle is operated in reverse order, the environment has to do positive work to the gas.

59. For a particular bacterium, its population growth in a test tube can be well described by the equation: $\frac{dN}{dt} = aN - \frac{bN^2}{c+N}$, where N is the bacterial population, which is always a finite number, and a, b, and c are positive numbers. Which of the following statements is *incorrect*?

(A) After a sufficiently long time, the population will become a fixed but non-zero number.
(B) The parameter b must be greater than a in order to ensure the population remains finite.
(C) The parameters a and b have the same unit.
(D) The rate of change in the population would oscillate and reach a steady state.
(E) None of the above.

60. A roller coaster has mass of 500 kg when fully loaded with passengers shown in the figure on the right. When the coaster passes through the bottom of a circular dip with a radius of 40 m (as shown in the figure) at a speed of 16.0 m/s. What is the magnitude of the force of the track on the coaster at the bottom of the dip?



(A) 0　(B) 1700N　(C) 3200N　(D) 4900N　(E) 8100N

國立清華大學 113 學年度學士後醫學系考試 各科試題參考答案

科目名稱：【0101 英文】

題號	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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科目名稱：【0102 生物與生化】

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科目名稱：【0104 資訊科學】

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國立清華大學 113 學年度學士後醫學系考試 各科試題參考答案

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