國立中山大學115學年度
碩士班考試入學招生考試試題

科目名稱：工程數學【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】

—作答注意事項—

考試時間：100分鐘

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※本科目依簡章規定「不可以」使用計算機(問答申論題)　　

1. $y' + (\tan x)y = \sin 2x \qquad y(0) = 2$ (10 pt)

2. $x^3y''' - x^2y'' - 2xy' + 6y = 7x^{-2}$ (Please use the method of undetermined coefficient. Otherwise, you will have no points by using other methods) (10 pt)

3. $(e^{x+y} + ye^y)dx + (xe^y - 1)dy = 0,\ y(0) = 1$ (10 pt)

4. $y'' - 5y' + 4y = 8e^x$ (Please use the method of undetermined coefficient. Otherwise, you will have no points by using other methods) (10 pt)

5. $y' + y = -\frac{x}{y},\ y(0) = 1$ (10 pt)

6. Find the Laplace transform (from t to s) and inverse Laplace transform (from s to t) for the following sub-questions (5 pt for each sub-question, 20 pt in total).

$(a)\ e^{3t}\sinh t \qquad (b)\ (a - bt)^2$

$(c)\ \frac{-s + 11}{s^2 - 2s - 3} \qquad (d)\ e^{-2s}/(s-1)^3$

7. Solve the coupled equations. (10 pt)

$y'_1 = y_2 + e^{2t}$

$y'_2 = y_1 - 3e^{2t}$

8. Solve the initial value problem by Laplace transform. (10 pt)

$y'' + y' - 6y = 0,\ y(0) = 1,\ y'(0) = 1$

9. Solve the initial value problem by Laplace Transform. (10 pt)

$y'' + 2y' - 3y = 0$

$y(2) = -3,\ y'(2) = -5$

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※本科目依簡章規定「不可以」使用計算機(混合題)

第一部分：單選題，每題 5 分，共計 50 分，答錯無倒扣

1. Which one of the following things will **not** happen when visible light travels from air into an amorphous solid medium? (A) Some of the light is diffracted by the solid. (B) Some of the light is absorbed by the sloid. (C) Some of the light is reflected at the air/solid interface. (D) Some of the light is transmitted through the solid. (E) Some of the light is scattered in the solid.

2. Which one of the following microstructural factors does **not** result in a consequence which cause a normally transparent material to become opaque? (A) A polycrystalline microstructure. (B) A two-phase microstructure. (C) A microstructure contains a high density of small pores. (D) A microstructure contains excess vacancies. (E) A highly crystalline polymer.

3. Which one of the following statements is **not** correct?
   (A) The magnetization (M) versus magnetic field (H) behavior for a ferromagnetic single crystal is anisotropic.
   (B) The crystallographic direction for which the saturation magnetization (M_s) is achieved at the lowest H field is an easy magnetization direction.
   (C) Below its Debye temperature, a ferromagnetic material is composed of domains in which all net dipole moments are mutually aligned and the magnetization is saturated.
   (D) Paramagnetic materials are those having permanent atomic dipoles, which are acted on individually and aligned in the direction of an external field.
   (E) The macroscopic magnetic properties of materials are a consequence of magnetic moments associated with individual electrons.

4. Which one of the following statement is **not** correct?
   (A) Most of the energy assimilated by many solid materials is associated with increasing the vibrational energy of the atoms.
   (B) Only specific vibrational energy values are allowed; a single quantum of vibrational energy is called a phonon.
   (C) For many crystalline solids at temperatures close to 0 K, the heat capacity measured at constant volume (*i.e.*, C_v) varies as the cube of the absolute temperature.
   (D) In excess of the Curie temperature, C_v becomes temperature independent.
   (E) Other energy absorptive mechanism, such as an electronic contribution in that electrons absorb energy by increasing their kinetic energy, also exist that can add to the total heat capacity of a solid.

5. Concerning the phenomenon that solids expand when heated and contract when cooled, which one of the following statements is correct?
   (A) The fraction change in length is proportion to the cube of temperature change.
   (B) Thermal expansion is reflected by an increase in the average atomic diameter.
   (C) The larger the average atomic weight, the lower the degree of thermal expansion.
   (D) The degree of thermal expansion for metals are typically greater than those for polymers.
   (E) The degree of thermal expansion for polymers are typically greater than those for ceramic materials.

6. Which of the following statements is correct?
   (A) A magnetic dipole is said to exist when there is a net spatial separation of positively and negatively charged entities on an atomic or molecular level.
   (B) Dielectric materials are electrical conductors that can be polarized when an electric field is present.

(C) The polarization phenomenon accounts for the ability of the dielectrics to increase the charge-storing capability of capacitors.
(D) Capacitance is dependent on applied current and quantity of electrons flowing through.
(E) The dialectic displacement within a dialectic medium depends on the applied magnetic field.

7. Which of the following statement is **not** correct?
(A) For intrinsic semiconductors, the electrical properties are inherent in the pure material and electron and hole concentrations are equal.
(B) Electrical behavior is dictated by dislocations for extrinsic semiconductors.
(C) With rising temperature, intrinsic carrier concentration increases dramatically.
(D) For extrinsic semiconductors, carrier concentration is independent of temperature in the extrinsic region.
(E) For extrinsic semiconductors, carrier mobility decreases, in general, with rising temperature.

8. Metallic corrosion is classified into nine different forms. Which one of the following phenomena is **not** within the nine forms?
(A) Scission.
(B) Erosion.
(C) Pitting.
(D) Hydrogen embrittlement.
(E) Selective leaching.

9. Which one of the following materials is **not** classified as ceramic materials?
(A) Glasses. (B) Clays. (C) Cements. (D) Refractories. (E) Polyesters.

10. Ceramics usually have a low strength in tension and a high strength in compression. The phenomenon is a result of (A) a weak interatomic bonding, (B) the presence of microscopic flaws, (C) the ease of oxidation, (D) a high elastic modulus, or (E) a low thermal conductivity.

第二部分：問答計算題，共計50分，答錯無倒扣

11. (a) Considering the solidification of nickel, derive the expression for the critical radius of nucleus, r^*, and the activation free energy, ΔG^*, in terms of latent heat of fusion (L_f), supercooling (ΔT) and solid/liquid interfacial energy (γ_{SL}) if nucleation is homogeneous and the interfacial energy is isotropic. (b) Explain why a smaller degree of supercooling is required for heterogeneous nucleation than for homogeneous nucleation. (8 points)

12. Both carbon dioxide (CO_2) and water (H_2O) begin to thermally decompose into carbon monoxide (CO) and oxygen (O_2), or into hydrogen (H) and oxygen (O) atoms at very high temperatures (>1700 °C). However, solid CO_2 (dry ice) sublimates into gaseous CO_2 at -78.5 °C and ice melts at 0 °C. What is the underlying reason for the substantial difference between the decomposition temperature and the sublimation/melting temperature? Please also explain why CO_2 has a sublimation temperature much lower than the melting temperature of ice? (8 points)

13. Nickel has a face-centered cubic crystal structure with a=0.3524 nm. Write down the formula used to calculate (a) the angle between the [110] and [211] directions, (b) the d-spacing of (220) plane, and (c) the two-theta (2θ) angle of (220) plane in a θ-2θ x-ray diffraction scan using Cu Kα radiation (λ=0.1541 nm). (9 points)

14. Using the isothermal transformation diagram (see **Fig. 1**) for a 4340 alloy steel, determine the final microstructure of a small specimen that has been subjected to the following heat treatment: (9 points)
    (a) Austenitize at 870 °C for 3600 s, rapidly cool to 650 °C and hold at this temperature for 3600 s, then quench to room temperature.
    (b) Austenitize at 870 °C for 3600 s, rapidly cool to 400 °C and hold at this temperature for 200 s, then quench to room temperature.
    (c) Austenitize at 870 °C for 1 h, then quench to room temperature.
    (Note: A: austenite; F: ferrite; P: pearlite; B: bainite; M: martensite)

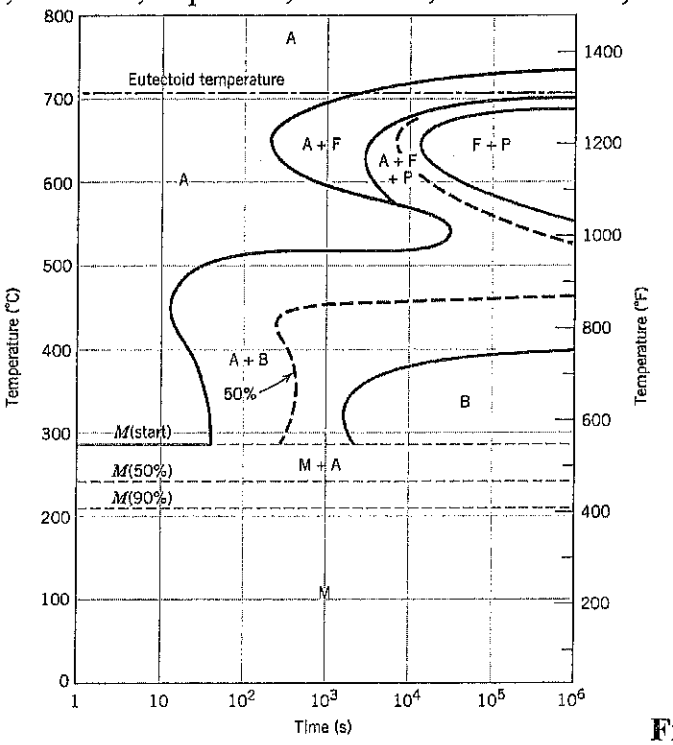

Figure 1.

15. Consider a steel bar of 20 mm in diameter that contains 0.1 wt% C and is to be treated at 950 °C. If the concentration of carbon at the surface is suddenly increased to and maintained at 1.1 wt%, *estimate* how long will it take to achieve a carbon content of 0.6 wt% at a position 0.1 mm below the surface? The diffusion coefficient for carbon in iron at 950 °C is 1.6×10^{-11} m^2/s. Explain how you estimate the time required. (8 points)

16. Consider the dislocation motion in nickel. (a) Please identify the slip plane(s) on which a screw dislocation with a Burgers vector of $\frac{1}{2}[110]$ can glide. (b) Please identify the slip plane(s) on which an edge dislocation extending along $[1\bar{2}\bar{1}]$ direction with a Burgers vector of $\frac{1}{2}[101]$ can glide. (8 points)

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題號：488003
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）　　共7頁第1頁

Single-choice questions
Instructions: For each question, you must identify the answer that best answer the question. There is only one correct answer for each question.
(3 points each)

1. Which of the following is a characteristic of ideal gas?
   a. Ideal gas particles are spherical with a non-zero volume.
   b. Ideal gas particles are identical.
   c. Ideal gases are always moving forward unless stopped.
   d. Ideal gases can be affected by gravity.

2. What is a practical application for the ideal gas law?
   a. Ideal gas law can be used to calculate pressure using temperature and volume of real gases.
   b. Ideal gas law can be used to quantitatively evaluate how real gases' pressure react to changes in temperature.
   c. Ideal gas law can be used to estimate the trend for changes in volume of real gases upon increasing pressure or temperature.
   d. Ideal gas law can be used to equate ideal gases to real gases.

3. What is the Van der Waals equation?
   a. Van der Waals equation is a variation of ideal gas law that has been modified to accommodate for real gases' volume and intermolecular interactions.
   b. Van der Waals equation is an evaluation of the strength of Van der Waals interactions in molecules.
   c. Van der Waals equation describes how distance affects the strength of Van der Waals attraction between two particles.
   d. Van der Waals equation is an wavefunction that describes the focal point of Van der Waals interactions.

4. What is the difference between enthalpy and internal energy?
   a. The enthalpy is the amount of energy available to do work and the internal energy is the amount of energy in a system.
   b. Internal energy is the total amount of energy available to a system, but enthalpy is the total energy in the system plus the energy in the surroundings.
   c. Internal energy is the energy in a system, and enthalpy is the extra energy that needs to be inputted to do work.
   d. PV

5. Which of the following is the best description of entropy?

a. Entropy is a measure of how fast the universe is expanding.
b. Entropy is a measure of the chaotic forces in the universe.
c. Entropy is a measure of the heat loss from a system to generate chaos.
d. Entropy is a measure of the randomness in a system.

6. Which of the following is an implication of the first law of thermodynamics?
   a. Mechanical energy can be transformed into heat with 100% efficiency.
   b. Heat cannot be transformed into electricity with 100% efficiency.
   c. Energy in a system is the sum of energy originally in the system and the energy transferred into or out of the system.
   d. Transform of any form of energy into heat can be done with 100% efficiency.

7. How can the second law of thermodynamics be used to characterize reversibility of chemical reactions or processes?
   a. Reactions that go forward will always increase entropy.
   b. Reactions that go forward will always decrease entropy.
   c. Reactions that are spontaneous will always increase entropy.
   d. Reactions that are non-spontaneous will always decrease entropy.

8. Which one of the following observations can be explained using the third law of thermodynamics?
   a. The concentration of intrinsic defects in a material approaches a constant as a material's temperature decreases.
   b. Crystal growth always requires temperatures below 200°C.
   c. Perfect crystals without any defects are the strongest form of a material.
   d. Enthalpy of formation for crystalline regions in a material increases as temperatures approach absolute zero.

9. What are the expectations of an adiabatic process?
   a. The system is an open system, with constant heat and materials exchange.
   b. The system is a standard closed system with only heat exchanges.
   c. The adiabatic process is not real because the conditions of an adiabatic process are mutually exclusive.
   d. The system of an adiabatic process does not lose heat to its surroundings.

10. When given a chemical process that is spontaneous according to thermodynamic calculations, the chemical process does not appear to be proceeding. What may be a suitable explanation for this outcome?
   a. The temperature is too low for the chemical process to occur.
   b. The process is too slow to observe.
   c. The chemical process does not have enough energy.
   d. The chemical process is statistically blocked from occurring.

11. What is the key difference between Helmholtz free energy and Gibbs free energy?
    a. Helmholtz free energy is the energy to predict spontaneity in confined spaces and Gibbs free energy is used to predict spontaneity in open spaces.
    b. Helmholtz free energy is used to evaluate if a reaction will proceed, and Gibbs free energy is to evaluate the energy required for a reaction to start.
    c. Helmholtz free is the evaluation of the energy required for a process to continue and Gibbs free energy evaluates if a process may begin.
    d. Helmholtz free energy must be used in isochoric conditions, and Gibbs free energy must be used in isobaric conditions.

12. Which of the following is a right sequence of steps for a Carnot cycle to generate work?
    a. Isothermal expansion, adiabatic compression, adiabatic expansion, isothermal compression.
    b. Isothermal compression, adiabatic compression, isothermal expansion, adiabatic expansion.
    c. Adiabatic expansion, isothermal expansion isothermal compression adiabatic compression.
    d. Adiabatic compression, adiabatic expansion, isothermal compression, isothermal expansion.

13. Which of the following is an effective and proper application of a thermodynamic cycle?
    a. Carnot cycles can be used to transform electricity to heat through thermodynamic energy loss.
    b. Carnot cycles can be used to transform geothermal energy directly into electricity.
    c. Rankine cycle can be used to recycle waste thermal energy into mechanical energy for electricity generation.
    d. Diesel cycle is the process by which fuels are generated from compressing carbon at increasing pressure with added thermal energy.

14. How can a thermodynamic work cycle be used to obtain a cooling device?
    a. A thermodynamic work cycle can be run in reverse.
    b. A thermodynamic work cycle can be cut in half to reduce the amount of heat generated and achieving cooling.
    c. When heat is inputted into the thermodynamic cycle the loss of heat at the heat source will achieve a cooling effect.
    d. Mechanical work can be extracted from the work cycle to remove heat and achieve cooling.

15. What is a limitation of Carnot cycles that prevents them from achieving 100% efficiency?
    a. Carnot cycles cannot be done in a vacuum.
    b. Carnot cycles cannot achieve 0 K temperature .

c. Carnot cycles cannot be done at high temperatures.
d. Carnot cycles is only applicable to ideal gases.

16. Which of the following is the best explanation for why there is a difference between heat capacity at constant volume (Cv) versus heat capacity at constant pressure(Cp)?
a. Cp must use heat to make the material's molecules move more, and Cv does not.
b. Cp must allow the material to expand, so the heat is more spread out compared to Cv.
c. Cp must increase the temperature of a larger amount of material, so Cp is greater than Cv.
d. Cp must account for the energy require to expand the system, and Cv does not.

17. What does heat capacity represent?
a. Heat capacity is the amount of heat required to heat up a kilogram of sample by 1 degrees Fahrenheit.
b. Heat capacity is the ability of a sample to store energy.
c. Heat capacity is the amount of heat or energy required to change the overall temperature of a sample by 1 degrees Celsius.
d. Heat capacity is the change in energy per unit temperature in kelvin.

18. Which one of the following is a correct statement for the heat capacity of materials when discussing phase transformations of materials.
a. A material with higher heat capacity would always phase transform faster than a material with lower heat capacity.
b. A material's heat capacity is always greater than the enthalpy of phase transformation because the molecules do not need to move during heat up.
c. Both of the above.
d. None of the above.

19. Differential scanning calorimetry is a technique often used to measure the thermal activity of an experimental system. If a solid crystalline sample is to melt in the experimental temperature range, how would this phenomenon be observed in the DSC thermogram with exothermic up?
a. The DSC thermogram would show a sharp positive peak for melting.
b. The DSC thermogram would show a sharp negative peak for melting.
c. The DSC thermogram would show a broad positive peak for melting.
d. The DSC thermogram would show a broad negative peak for melting.

20. Eutectic phase diagrams are the results of miscibility gaps in mixtures at different conditions. How do miscibility gaps occur?
a. Mixtures of two or more components often exhibit miscibility gap due to incompatibility in molecular interactions.
b. When materials are too different, such as according to Hume-Rothery rules, the atoms give off energy as they form solutions.

c. A mixture's homogeneous interactions are less energetic than heterogeneous interactions.
d. A mixture does not have the required energy for the mixing process to occur.

21. Raoult's law describes the ideal behaviors of mixtures. Can mixtures that follow Raoult's law generate a eutectic behavior? Why or why not?
a. Yes, all mixture can have eutectic behavior.
b. No, Raoult's law describes ideal particles with the same behaviors.
c. No, Raoult's law describes ideal particles, which are not real.
d. No, Raoult's law describes ideal particles that are indistinguishable, so they cannot form phases.

22. Solutions are homogeneously mixed mixtures, which of the following is true about solutions?
a. Only liquids can form solutions.
b. Liquid solutions can form from every liquid combination because they have high molecular mobility.
c. Liquid solutions can have long range order due to discrete and stable intermolecular interactions.
d. Solutions can form between solids.

23. What's the reason for a vapor dome formation in a P-V phase diagram?
a. The vapor dome forms because the free energy of both gas and liquid phases are equal in the state.
b. The vapor dome forms from immiscibility between the components in the material system.
c. The vapor dome forms because the material is in the transition from liquid to gas, and the process takes time.
d. The vapor dome forms because it is an intermediate biphasic state between gas and liquid that allows the material to rapidly change temperature.

24. Why does spinodal decomposition occur from homogeneous solutions?
a. Spinodal decomposition is an event that causes the material to split into two distinct phases.
b. Spinodal decomposition is when a material solution can decrease the overall energy by splitting into two distinct phases.
c. Spinodal decomposition is an event when a material cools down from liquid phase, and the material generate two different phases upon cooling.
d. Spinodal decomposition is a completely random occurrence that depends on chance.

25. What are the differences between canonical ensemble versus grand canonical ensemble when doing statistical thermodynamics?

a. Canonical ensemble does not allow particle exchange, and grand canonical ensemble allows particles to exchange between two finite reservoir.
b. Canonical ensemble allows heat exchange with the surrounding, grand canonical ensemble does not allow heat exchange.
c. Canonical ensemble is best suited for an open system, and a grand canonical ensemble is suitable for a closed system.
d. Canonical ensemble only allow energy exchange with surrounding, and grand canonical ensemble allows both energy and particle exchange with the surrounding.

Long Answer questions
Instructions: The questions require more extensive work and calculations. Please circle your final answers. Some questions may require an explanation, please circle your explanations.

26. You found two of your friends arguing about the formation mechanism of "Brine pools" at the bottom of oceans. Examine their arguments and answer the question.

Friend Sally: *"Brine pools form from the dissolution of NaCl into the water. Because the salt is very soluble, this causes some water to be denser than others. We know that denser material sinks to the bottom of the ocean, so brine pools are just the denser salt solutions sinking down."*
Friend Jonas: *"Brine pools are formed from the bottom up. When water sits on top of salt deposits at the bottom of the ocean, geothermal heat helps the deeper water dissolve salt. As the salt diffuses, the colder water above cannot dissolve the high concentration salt and the salt precipitates out. This generates a pool of highly concentration brine pool at the bottom of the ocean."*
Question - Which one of the two friends is correct? Are they both correct? Or are they both wrong? Explain your answer with reasoning in less than 50 words. (8 points)

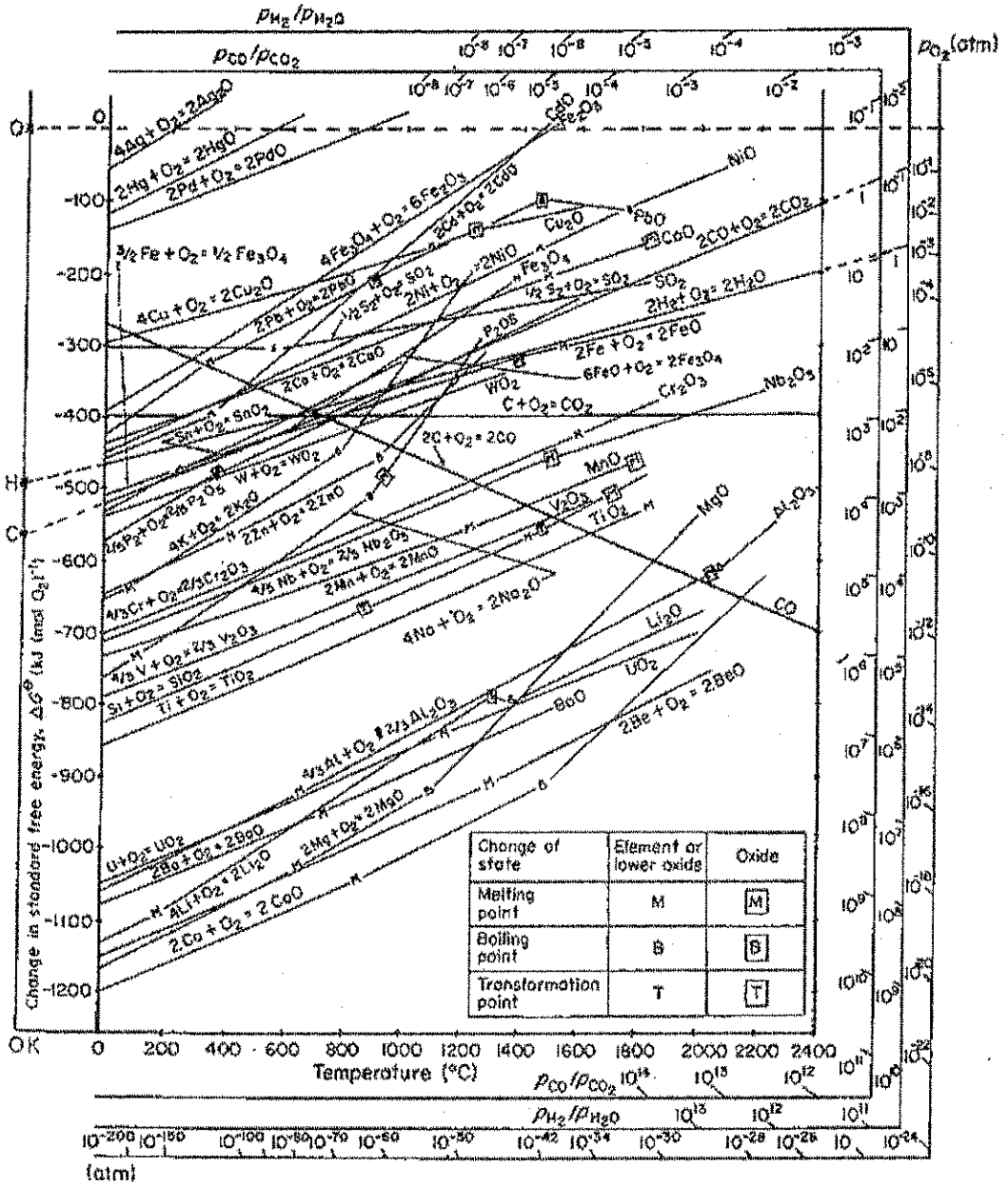
27. Van der Waals equation can be used help one evaluate real gases. Answer the following questions regarding Van der Waals equation.
    a. What is the Van der Waals equation? **(4 points)**
    b. Mathematically, how does the Van der Waals equation account for mutually excluded volume for spherical real gases? **(4 points)**

28. Using the provided Ellingham diagram below, answer the following questions.
    a. Why do most reactions have positive slopes in the Ellingham diagrams? **(5 points)**
    b. If you are to choose a sacrificial component in a Fe-based alloy, which element would you choose? Why? **(4 points)**

國立中山大學115學年度碩士班考試入學招生考試試題

科目名稱：基礎熱力學【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】
題號：488003

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）　　



國立中山大學115學年度
碩士班考試入學招生考試試題

科目名稱：普通化學【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】

—作答注意事項—

考試時間：100分鐘

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國立中山大學115學年度碩士班考試入學招生考試試題

科目名稱：普通化學【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】題號：488004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）(混合題)　　

Part I-Multiple-Choice Questions - Select the ONE best answer for each question (2% for each question, 80% in total)

1. For a certain reaction, $\Delta H = -45\ kJ \cdot mol^{-1}$ and $\Delta S = -120\ J \cdot mol^{-1} \cdot K^{-1}$. At which temperature range is this reaction spontaneous?
A. Only at high temperature　　B. Only at low temperature
C. At all temperatures　　D. At no temperature

2. Which statement correctly describes a state function?
A. It depends only on the path taken　　B. It depends only on the initial and final states
C. It never changes during a reaction　　D. It must be conserved

3. Which process produces the largest increase in entropy?
A. Freezing water　　B. Mixing ethanol and water
C. Sublimation of dry ice　　D. Precipitation of a salt

4. For the reaction $2A(g) \rightarrow B(g)$, the equilibrium constant K_p is 4.0 at a certain temperature. What is ΔG° at this temperature?
A. $-RT \ln 4$　　B. $+RT \ln 4$
C. $-2RT \ln 4$　　D. $+2RT \ln 4$

5. Which statement about Gibbs free energy is correct?
A. A negative ΔG guarantees a fast reaction
B. A reaction with positive ΔG cannot occur
C. ΔG indicates thermodynamic favorability only
D. ΔG depends only on ΔH

6. For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, which change shifts the equilibrium toward NO_2?
A. Decreasing temperature　　B. Increasing volume of the container
C. Adding an inert gas at constant volume　　D. Increasing pressure

7. A weak acid HA has $K_a = 1.0 \times 10^{-5}$. Which statement is true?
A. HA is fully dissociated　　B. $[H^+] \approx [A^-]$ in pure HA solution
C. The conjugate base is weak　　D. The solution pH must be 7

8. Which pair of substances best forms a buffer solution?
A. HCl and NaCl　　B. NaOH and NaCl
C. CH_3COOH and $NaCH_3COO$　　D. HNO_3 and $NaNO_3$

9. Which statement correctly describes Le Châtelier' s principle (勒沙特列原理)?
A. Catalysts shift equilibrium toward products
B. Removing product drives the reaction forward
C. Dilution always favors reactants
D. Increasing temperature always increases K

10. For a salt MX2 with solubility s mol·L^{-1}, what is K_{sp}?
A. s　　B. 2s
C. $4s^2$　　D. $4s^3$

11. Which factor does NOT affect the rate constant k?
A. Temperature　　B. Activation energy
C. Presence of a catalyst　　D. Initial concentration

12. A reaction is second-order in reactant A. Which plot yields a straight line?
A. [A] vs t　B. ln[A] vs t　C. 1/[A] vs t　D. $[A]^2$ vs t

13. For a multi-step mechanism, the rate law is determined by:
A. The fastest step　　B. The slowest step
C. The number of steps　　D. The equilibrium step

14. Why does increasing temperature generally increase reaction rate?
A. ΔH becomes more negative
B. More molecules exceed the activation energy
C. The reaction mechanism changes
D. The reactant concentration increases

15. Which molecule is predicted to be non-polar?
A. NH_3　　B. H_2O　　C. CO_2　　D. SO_2

16. Which statement about hybridization is correct?
A. sp2 corresponds to tetrahedral geometry
B. sp3 corresponds to trigonal planar geometry
C. sp corresponds to linear geometry
D. sp2 corresponds to linear geometry

17. Which molecule contains delocalized π-electrons?
A. Ethane　　B. Ethene　　C. Benzene　　D. Methanol

18. Which quantity generally increases across a period from left to right?
A. Atomic radius　　B. Metallic character
C. Ionization energy　　D. Ionic radius

19. In a galvanic cell:
A. Reduction occurs at the anode　　B. Oxidation occurs at the cathode
C. Electrons flow from anode to cathode　　D. A power supply is required

20. Colligative properties depend primarily on:
A. Solute molar mass　　B. Solute identity
C. The number of dissolved particles　　D. Solute polarity

21. For an ideal gas, which statement correctly describes internal energy?
A. It depends only on volume　　B. It depends only on pressure
C. It depends only on temperature　　D. It is always constant

22. Which of the following processes is endothermic?
A. Condensation of steam　　B. Freezing of water
C. Melting of ice　　D. Formation of NaCl(s)

23. Which gas behaves most ideally at room temperature?
A. NH_3　　B. H_2O　　C. CO_2　　D. He

24. The compressibility factor $Z = PV/nRT$. If $Z < 1$, what interaction dominates?
A. Repulsive　　B. Attractive　　C. Neither　　D. Nuclear

25. When two gases mix spontaneously:
A. $\Delta S < 0$　　B. $\Delta S = 0$　　C. $\Delta S > 0$　　D. $\Delta G > 0$

26. For a reaction where $\Delta G^\circ < 0$, which statement must be true?
A. $K = 1$　　B. $K < 1$　　C. $K > 1$　　D. $K = 0$

27. Which solution has the lowest pH?
A. 0.10 M CH_3COOH　　B. 0.10 M HF
C. 0.10 M HCl　　D. 0.10 M NH_4Cl

28. For a weak acid HA, which expression is correct?
A. $K_a = [HA]/[H^+][A^-]$　　B. $Ka = [H^+][A^-]/[HA]$　　C. $Ka = 1/[H^+]$
D. $K_a = pH$

29. When NaOH is added to a buffer composed of HF and NaF:
A. pH decreases　　B. pH increases slightly
C. pH does not change　　D. The buffer is destroyed immediately

30. If $Q < K$ for a reaction mixture:
A. The system is at equilibrium　　B. The reaction shifts toward products
C. The reaction shifts toward reactants　　D. The reaction stops

31. If a reaction is first-order in A and first-order in B, the rate law is:
A. k[A]　　B. k[B]　　C. k[A][B]　　D. $k[A]^2[B]$

32. Which statement about catalysts is correct?
A. Catalysts increase ΔG　　B. Catalysts lower activation energy
C. Catalysts shift equilibrium　　D. Catalysts are consumed

33. According to the Arrhenius equation:
A. k increases as E_a increases　　B. k decreases as temperature increases
C. k increases as temperature increases　　D. k is independent of E_a

34. The half-life of a first-order reaction:
A. Depends on concentration　　B. Is constant
C. Decreases over time　　D. Is zero

35. A mechanism includes a fast equilibrium followed by a slow step. The observed rate law will depend on:
A. Only products　　B. Only the fast step
C. Only the slow step　　D. Both steps through substitution

36. Which molecule violates the octet rule by having fewer than eight electrons?
A. CO_2　　B. BF_3　　C. NH_3　　D. H_2O

37. Which species has the largest radius?
A. Na^+　　B. Mg^{2+}　　C. Ne　　D. Cl^-

38. Which molecule is expected to have the highest dipole moment?
A. CO_2　　B. CF_4　　C. $CHCl_3$　　D. CCl_4

39. Which species exhibits resonance?
A. CH_4　　B. CO　　C. NO^{3-}　　D. NH^{4+}

40. Which diatomic molecule is paramagnetic (順磁性)?
A. N_2　　B. O_2　　C. F_2　　D. CO

Part II-Calculation Questions (20%)

1. A 0.1 M aqueous solution of acetic acid, CH_3COOH, has an acid dissociation constant $K_a=1.8 \times 10^{-5}$
(a)Calculate the equilibrium $[H^+]$ and the pH of the solution.(5%)
(b)Calculate the percent ionization of acetic acid in this solution.(5%)

國立中山大學115學年度碩士班考試入學招生考試試題

科目名稱：普通化學【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】題號：488004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）(混合題)　　

2. When 6.00 g of solid sodium hydroxide (NaOH) is dissolved in 200.0 g of water in a coffee-cup calorimeter, the temperature of the solution increases from 25.0 °C to 32.0 °C.

   Assuming that:

   - The solution has the same density and specific heat capacity as water ($c = 4.18\ J\ g^{-1}C^{-1}$),
   - No heat is lost to the surroundings or the calorimeter,

   calculate the molar enthalpy change of dissolution of NaOH ($\Delta H_{(diss)}$) in $kJ \cdot mol^{-1}$.

   State whether the process is endothermic or exothermic. (10%)

國立中山大學115學年度
碩士班考試入學招生考試試題

科目名稱：普通物理【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】

—作答注意事項—

考試時間：100分鐘

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國立中山大學115學年度碩士班考試入學招生考試試題

科目名稱：普通物理【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】
題號：488005
※ 本科目依簡章規定「不可以」使用計算機（問答申論題）　　

Problem 1. [Mechanics: 35 points]

(a) [10 points] A ball with mass m is attached to the wall with a spring, as shown in Fig. 1. The elastic constant of the spring is k. Use Newton's second law, $F = m\frac{d^2x}{dt^2}$, solve the $x(t)$ and the augular frequency ω.

(b) [10 points] If the ball is displaced by $+A$ from the equilibrium position, and then release at the time $t = 0$. After releasing, the ball oscillates harmonically between $x = +A$ and $-A$. What is the potential energy for the ball to be at an arbitrary time t?

(c) [10 points] Following the above question, what is the kinetic energy for the ball to be at an arbitrary time t?

(d) [5 points] Following the above question, what is the total energy for the ball to be at an arbitrary time t? Is the energy conserved?

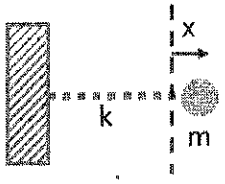

Figure 1

Problem 2. [Electromagnetism: 30 points]

The electric field at a distance $\boldsymbol{r}$ from a point charge Q is:

$$\mathbf{E} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{\boldsymbol{r}},$$

where $\hat{\boldsymbol{r}}$ is the unit vector along the vector $\boldsymbol{r}$. The electric potential is:

$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}$$

Consider the following questions in the vacuum, and **use the units in the above formula.**

(a) [10 points] Find the electric field inside a solid ball of radius R that carries a uniform volume charge density ρ. Express your answer in terms of the total charge q of the ball.

(b) [10 points] Find the electric potential inside a solid ball of radius R that carries a uniform volume charge density ρ. Express your answer in terms of the total charge q of the ball.

(c) [10 points] Using the potential obtained in (c), find the electric field inside a solid ball of radius R that carries a uniform volume charge density ρ. Express your answer in terms of the total charge q of the ball.

Problem 3. [Thermodynamics: 25 points]

n moles of ideal gas doubles its volume from V_0 to $2V_0$ in a free expansion. The process is assumed to be isothermal (temperature is a constant) by attaching to a thermal reservoir.

(a) [5 points] The heat

$$dQ = pdV + nC_v dT$$

where p is the pressure, dV is the volume change, n is the number of moles, C_V is the specific heat, and dT is the temperature change. Calculate dQ in this isothermal free expansion process.

(b) [5 points] The entropy change in this process is:

$$dS = \frac{dQ}{T}$$

Calculate the entropy change using the result from the obtained dQ.

(c) [5 points] The entropy per mole of gas can also be defined in a statistical point of view:

$$S = R \ln W$$

where R is the universal gas constant, and W is the muliplicity of microstates. n moles of gas are initially in the left half of the container, while there are 0 moles in the right half of the container. Calculate the multiplicity of the initial configuration (how many possible ways to distribute n moles into the two halves, with n moles in the left half and 0 moles in the right half).

(d) [5 points] After the expansion, $n/2$ moles of gas are in the left half of the container, and $n/2$ moles are in the right half of the container. Calculate the multiplicity of this final configuration (how many possible ways to distribute n moles into the two halves, with $n/2$ moles in the left half and $n/2$ moles in the right half).

(e) [5 points] Use the above two results for the entropy before and after the free expansion, calculate the entropy change $dS = R \ln W_{\text{final}} - R \ln W_{\text{initial}}$. (hint: Stirling's approximation $\ln N! \approx N \ln N - N$)

Problem 4. [Waves/Optics/Modern physics: 10 points]

A propagating wave with a wavelength λ and oscillation period T along the x direction has the form $f(x,t) = Ae^{i(kx-\omega t+\phi)}$, where x is the position, t is the time, A is a constant amplitude and ϕ is a constant phase.

(a) [5 points] Using the fact that the wave is periodic in space, $f(x+\lambda, t) = f(x,t)$, derive the relation of k and λ.

(b) [5 points] Using the fact that the wave is periodic in time, $f(x, t+T) = f(x,t)$, derive the relation of ω and T.

國立中山大學115學年度
碩士班考試入學招生考試試題

科目名稱：工程數學【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】

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國立中山大學115學年度碩士班考試入學招生考試試題

科目名稱：工程數學【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】題號：488001

※本科目依簡章規定「不可以」使用計算機(問答申論題)　　

1. $y' + (\tan x)y = \sin 2x \qquad y(0) = 2$ (10 pt)

2. $x^3y''' - x^2y'' - 2xy' + 6y = 7x^{-2}$ (Please use the method of undetermined coefficient. Otherwise, you will have no points by using other methods) (10 pt)

3. $(e^{x+y} + ye^y)dx + (xe^y - 1)dy = 0,\ y(0) = 1$ (10 pt)

4. $y'' - 5y' + 4y = 8e^x$ (Please use the method of undetermined coefficient. Otherwise, you will have no points by using other methods) (10 pt)

5. $y' + y = -\frac{x}{y},\ y(0) = 1$ (10 pt)

6. Find the Laplace transform (from t to s) and inverse Laplace transform (from s to t) for the following sub-questions (5 pt for each sub-question, 20 pt in total).

$(a)\ e^{3t}\sinh t \qquad (b)\ (a - bt)^2$

$(c)\ \frac{-s + 11}{s^2 - 2s - 3} \qquad (d)\ e^{-2s}/(s-1)^3$

7. Solve the coupled equations. (10 pt)

$$y'_1 = y_2 + e^{2t}$$

$$y'_2 = y_1 - 3e^{2t}$$

8. Solve the initial value problem by Laplace transform. (10 pt)

$y'' + y' - 6y = 0,\ y(0) = 1,\ y'(0) = 1$

9. Solve the initial value problem by Laplace Transform. (10 pt)

$y'' + 2y' - 3y = 0$

$y(2) = -3,\ y'(2) = -5$