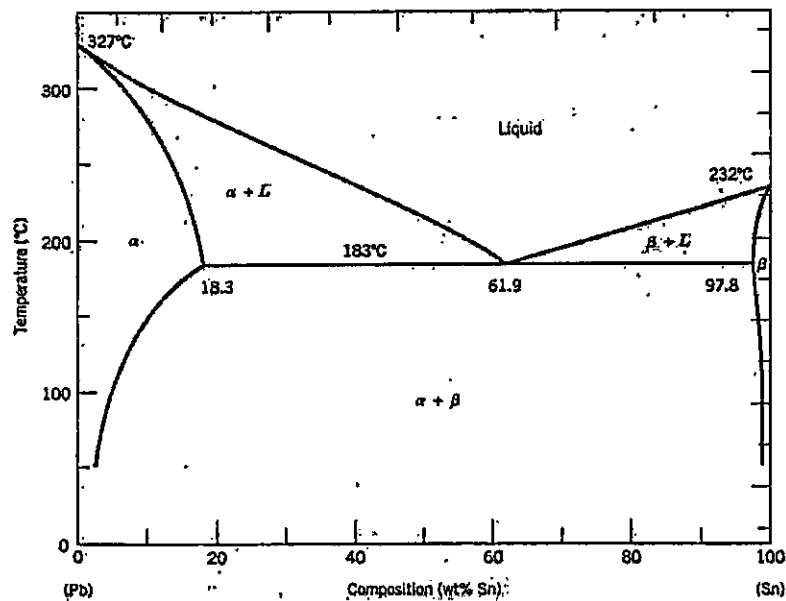




1. BCC titanium, with a lattice parameter of 3.32\AA , transforms to an HCP structure on cooling. The HCP structure has lattice parameters $a=2.98\text{\AA}$ and $c=2.9074\text{\AA}$. Calculate the volume change during cooling. Does titanium expand or contract on cooling? (10%)
2. Derive Bragg's law by using the simple case of incident x-ray beams being diffracted by parallel planes in a crystal. (10%)
3. 10 kg of an alloy of 70% Pb and 30% Sn is slowly cooled from 300°C . Refer to the lead-tin phase diagram and calculate the following:
 - (a) The weight percent of the liquid and proeutectic alpha at 250°C .
 - (b) The weight percent of the liquid and proeutectic alpha just above the eutectic temperature (183°C) and the weight in kilograms of these phases.
 - (c) The weight in kilograms of alpha and beta formed by the eutectic reaction.



(10%)

4. What are five important factors which affect the recrystallization process in metals? (10%)
5. (a) Describe the relation between engineering strain and true strain.
 (b) What is the general relationship between the flow stress and the dislocation density? (10%)



6. Compute the atomic packing factor for cesium chloride crystal structure in which $r_{\text{Cs}^+}/r_{\text{Cl}^-} = 0.732$. (10%)
7. (a) Differentiate between polymorphism and isomerism. (4%)
(b) Sketch portions of a linear polystyrene molecule that are (1) syndiotactic, (2) atactic, and (3) isotactic. (6%)
8. (a) Why does chromium in stainless steels make them more corrosion resistant in many environments than plain carbon steels? (5%)
(b) Explain why cold-worked metals are more susceptible to corrosion than noncold-worked metals. (5%)
9. In terms of electron energy band structure, discuss reasons for the difference in electrical conductivity between metals, semiconductors, and insulators. (10%)
10. (a) Briefly explain how reflection losses of transparent materials are minimized by thin surface coatings. (7%)
(b) Briefly describe the three adsorption mechanisms in nonmetal materials. (3%)



本試題共九題，共計 100 分，請依題號作答並將答案寫在答案卷上，違者不予計分。

1. For each of the following, evaluate the limit or show that the limit does not exist.

$$(a). \lim_{x \rightarrow 2} f(x) = ? \text{ where } f(x) = \begin{cases} x^2 + 3x & \text{for } x \leq 2 \\ -5x + 20 & \text{for } x > 2 \end{cases} \quad (5\%)$$

$$(b). \lim_{x \rightarrow 4} \left[\left(\frac{1}{x} - \frac{1}{4} \right) \left(\frac{1}{x-4} \right) \right] = ? \quad (5\%)$$

$$(c). \lim_{x \rightarrow 0} x \cot(3x) = ? \quad (5\%)$$

$$(d). \lim_{x \rightarrow \infty} \frac{\sin(x) \cos(x)}{x^2 + 1} = ? \quad (5\%)$$

$$(e). \lim_{x \rightarrow 0} \left(\frac{1}{x \sin(x)} - \frac{1}{x^2} \right) = ? \quad (5\%)$$

2. Let

$$f(x) = \begin{cases} Ax - B & \text{for } x \leq 1 \\ 3x & \text{for } 1 < x < 2 \\ Bx^2 - A & \text{for } 2 \leq x \end{cases} \quad (5\%)$$

Find values for A and B for which f is continuous at $x = 1$ and discontinuous at $x = 2$.

3. Find the global maximum and global minimum of the following function

$$f(x) = \begin{cases} x^2 + 2x + 2 & \text{for } -1/2 \leq x \leq 0 \\ x^2 - 2x + 2 & \text{for } 0 < x \leq 2 \end{cases} \quad (10\%)$$

4. Two runners P and Q start at the origin and run along the positive x -axis, with Q running 3 times as fast as P . An observer, standing one unit above the origin (Figure 1), keeps P and Q in view. What is the maximum angle of sight θ between the observer's view of P and Q . (10%)

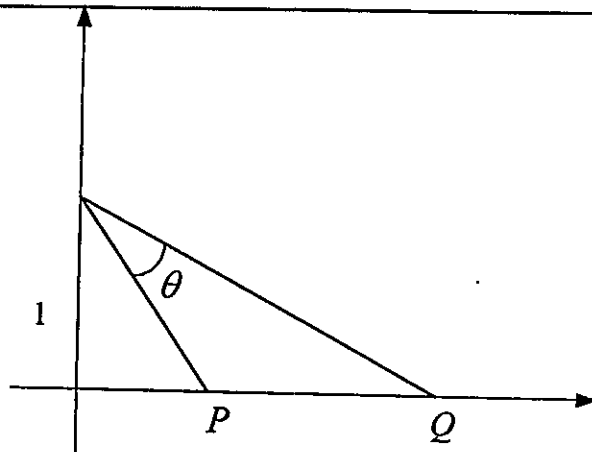


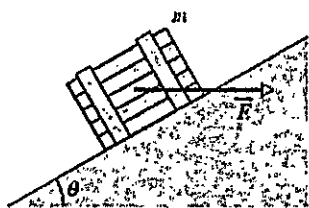
Figure 1.

5. 試求 $\lim_{x \rightarrow \infty} (1 + \sin \frac{3}{x})^x = ?$ (10%)
6. 試找出由 $x=0$ 到 $x=2\pi$ ，介於 $y = \sin x$ 和 $y = \cos x$ 之間的面積。(10%)
7. 試求函數 $f(x, y) = x^4 + y^4 - 4xy$ 的相對極小值。(10%)
8. 試找出位於橢圓 $4x^2 + y^2 = 4$ 上但離開 $(1, 0)$ 點最遠的點的座標。(10%)
9. 試找出常數 c 使得函數 $g(x) = \begin{cases} x^2 - c^2 & x < 4 \\ cx + 20 & x \geq 4 \end{cases}$ 在 $(-\infty, \infty)$ 連續。(10%)

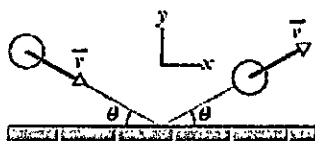


(每題 10 分)

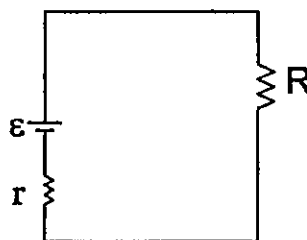
- 如圖(1)，一個質量為 100 公斤的箱子受到一水平力量 F 沿著一無摩擦的斜坡($\theta = 30^\circ$)往上移動，求(a) F 的大小；(b) 斜坡作用於箱子的力量。
- 一大小為 12 N 的力量以一固定的方向作用於一質點，質點的位移為 $\vec{d} = (2.00\vec{i} - 4.00\vec{j} + 3.00\vec{k})$ 公尺。如果質點的動能改變為(a) $+30.0\text{ J}$ ；(b) -30.0 J 求力量和位移之間的夾角。
- 如圖(2)，一個 300 克的球速度大小為 6 m/s ，撞擊牆壁之角度 $\theta = 30^\circ$ ，並以相同的速度大小及角度反彈。球和牆壁接觸的時間是 10 ms ，求(a) 牆壁對球所作用衝量大小；(b)碰撞期間，球對牆壁之平均作用力。
- 有一個物體連結一個彈簧($k = 400\text{ N/m}$)作簡諧運動。在某個時間點，物體之位置(從平衡處量起)、速度和加速度分別為 $x = 0.100\text{ m}$ 、 $v = -13.6\text{ m/s}$ 及 $a = -123\text{ m/s}^2$ 。求(a)震盪之頻率；(b)物體之質量；(c)運動之振幅。
- 有甲乙兩容器完全絕熱，體積都是 V 。甲容器內有理想氣體 n 莫耳，乙容器為真空，兩容器之間以閥隔離。現在打開閥門，讓甲容器內氣體自由膨脹(free expansion)進入乙容器，求此系統內能之改變及溫度之變化。
- 銅質導體的電阻溫度係數約為 $3.9 \times 10^{-3}\text{ }^\circ\text{C}^{-1}$ 。請問在那一個溫度下，銅的電阻會是它在 0°C 時電阻的兩倍？
- 假設在一次典型的閃電中，兩個放電點的電位差是 10^9 V ，轉移的電荷量約為 30 C ，若釋放出的電能都用來使 0°C 的冰融化成 0°C 的水，則可以融化多少冰？(冰的融化熱為 $3.34 \times 10^5\text{ J}\cdot\text{kg}^{-1}$)
- (a)根據 Maxwell 方程式，產生磁場的來源有哪兩種？
(b)寫出所根據的 Maxwell 方程式。
- 如圖(3)中電路電池的內電阻 r ，電阻器電阻 R ，則
(a)請求出電阻的消耗功率 P 。
(b)請求出 R 為多少時有最大消耗功率。
- 寬 4.5 mm 且厚度 $150\text{ }\mu\text{m}$ 的銅片，置於大小為 0.65 T 的磁場 \vec{B} 中。 \vec{B} 與銅片垂直。電流 $i = 23\text{ A}$ 流入銅片後，銅片於寬度的兩端產生了 Hall 電位差 V 。(每立方公尺的銅有 8.47×10^{28} 個電子)，請求出 Hall 電位差。



圖(1)



圖(2)



圖(3)



- 一、選擇題（每題 2 分，共計 50 分，請依題號作答，並將答案寫在答案卷上，違者不與計分）
- What is $5.6792\text{ m} + 0.6\text{ m} + 4.33\text{ m}$ expressed in the correct units with the correct number of significant figures?
 (A) 10.6 m (B) 10.60 m (C) 10.61 m (D) 10.6092 m
 - What temperature is $95\text{ }^\circ\text{F}$ when converted to degrees Celsius?
 (A) $63\text{ }^\circ\text{C}$ (B) $35\text{ }^\circ\text{C}$ (C) $127\text{ }^\circ\text{C}$ (D) $15\text{ }^\circ\text{C}$
 - The diameter of a neutral helium atom is about $1 \times 10^2\text{ pm}$. Suppose that we could line up helium atoms side by side in contact with one another. Approximately how many atoms would it take to make the distance from end to end 1 cm?
 (A) $1 \times 10^8\text{ He atoms}$ (B) $2 \times 10^5\text{ He atoms}$ (C) $1 \times 10^9\text{ He atoms}$ (D) $5 \times 10^6\text{ He atoms}$
 - What is the number of protons, neutrons, and electrons in $^{63}_{29}\text{Cu}$?
 (A) 29 protons, 34 neutrons, 34 electrons (B) 29 protons, 34 neutrons, 29 electrons
 (C) 34 protons, 29 neutrons, 34 electrons (D) 29 protons, 63 neutrons, 29 electrons
 - Group the following elements in pairs that you would expect to show similar chemical properties: K, F, P, Na, Cl, and N.
 (A) K/N; F/Na; Cl/N (B) K/Na; F/Cl; P/N (C) K/F; P/Na; Cl/N (D) K/P; F/Na; Cl/N
 - Which pair of compounds has the same empirical formula?
 (A) $\text{C}_2\text{H}_6\text{O}_3$ and CH_2O (B) NO_2 and N_2O_4 (C) C_6H_6 and CH_4 (D) NO_2 and NO_4
 - Which of the following compounds is named lithium carbonate?
 (A) Na_2CO_3 (B) LiHCO_3 (C) LiCO (D) Li_2CO_3
 - How many atoms are there in 5.10 moles of sulfur (S)?
 (A) 3.07×10^{24} (B) 9.59×10^{22} (C) 6.02×10^{23} (D) 9.82×10^{25}
 - Peroxyacetyl nitrate (PAN) is one of the components of smog. It is a compound of C, H, N, and O. Determine the empirical formula from the following percent composition by mass: 19.8 percent C, 2.50 percent H, 11.6 percent N, 66.1 percent O. What is its molecular formula given that its molar mass is about 120 g? C:12g/mol, O:16g/mol, H:1g/mol, N:14g/mol
 (A) C_2HNO_6 (B) $\text{C}_2\text{H}_3\text{NO}_5$ (C) $\text{CH}_5\text{N}_2\text{O}$ (D) $\text{C}_3\text{H}_6\text{N}_4\text{O}_3$
 - Which of the following equations is balanced?
 (A) $\text{CO}_2 + 2\text{KOH} \rightarrow \text{K}_2\text{CO}_3 + 2\text{H}_2\text{O}$ (B) $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
 (C) $\text{Be}_2\text{C} + \text{H}_2\text{O} \rightarrow 2\text{Be}(\text{OH})_2 + \text{CH}_4$ (D) $\text{Cu} + 2\text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + \text{NO} + \text{H}_2\text{O}$



11. For the following reaction: $4\text{Na}(s) + \text{O}_2(g) \rightarrow 2\text{Na}_2\text{O}(s)$, which species is the oxidizing agent?
 (A) Na (B) O_2 (C) Na_2O (D) this is not a redox reaction
12. How many moles of MgCl_2 are present in 60.0 mL of 0.100 M MgCl_2 solution?
 (A) 60.0 moles (B) 0.572 moles (C) 6.00×10^{-3} moles (D) 6.00 moles
13. Calculate the volume in mL of a 1.420 M NaOH solution required to titrate 25.00 mL of a 4.500 M H_2SO_4 solution.
 (A) 56.25 mL (B) 158.5 mL (C) 112.5 mL (D) 225.0 mL
14. Oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$) is present in many plants and vegetables. If 24.0 mL of 0.0100 M KMnO_4 solution is needed to titrate 1.00 g of a sample of $\text{H}_2\text{C}_2\text{O}_4$ to the equivalence point, what is the percent by mass of $\text{H}_2\text{C}_2\text{O}_4$ in the sample? The net ionic equation is:
 $2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_2\text{C}_2\text{O}_4 \rightarrow 2\text{Mn}^{2+} + 10\text{CO}_2 + 8\text{H}_2\text{O}$. (C:12g/mol, O:16g/mol, H:1g/mol)
 (A) 2.40 % (B) 54.0 % (C) 3.69 % (D) 5.40 %
15. A gas-filled balloon having a volume of 2.50 L at 1.2 atm and 25°C is allowed to rise to the stratosphere (about 30 km above the surface of Earth), where the temperature and pressure are -23°C and 3.00×10^{-3} atm, respectively. Calculate the final volume of the balloon.
 (A) 660 L (B) 840 L (C) 920 L (D) 10,000 L
16. In alcohol fermentation, yeast converts glucose to ethanol and carbon dioxide:
 $\text{C}_6\text{H}_{12}\text{O}_6(s) \rightarrow 2\text{C}_2\text{H}_5\text{OH}(l) + 2\text{CO}_2(g)$
 If 5.97 g of glucose are reacted and 1.44 L of CO_2 gas are collected at 293 K and 0.984 atm, what is the percent yield of the reaction? (C:12g/mol, O:16g/mol, H:1g/mol)
 (A) 50.6% (B) 77.2% (C) 88.9% (D) 100.%
17. A 6.22-kg piece of copper metal is heated from 20.5°C to 324.3°C . Calculate the heat absorbed (in kJ) by the metal. The specific heat of Cu is $0.385 \text{ J/g}^\circ\text{C}$.
 (A) 7.28×10^{-4} kJ (B) 0.728 kJ (C) 728 kJ (D) 7.28×10^5 kJ
18. What is the wavelength (in nanometers) of light having a frequency of $8.6 \times 10^{13} \text{ Hz}$?
 (A) 3.5 nm (B) 3.5×10^3 nm (C) 3.5×10^6 nm (D) 2.9×10^5 nm
19. Six valence electrons are present in _____.
 (A) Si (B) B (C) I (D) S

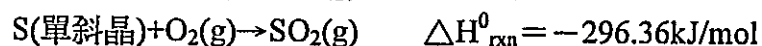


20. The correct order of radius of an atom, A, to its ion is _____.
 (A) $A^- < A$ (B) $A^{2+} < A^+$ (C) $A^{2+} > A$ (D) $A^+ > A^-$
21. Which of the following is not a periodic property?
 (A) atomic radius (B) ionization energy (C) atomic volume (D) density
22. The element having five electrons in the valence shell is _____.
 (A) Al (B) N (C) S (D) Se
23. In an ionic compound, _____.
 (A) the cation is a metal and the anion is the non-metal
 (B) the anion is the metal and the cation is the non-metal
 (C) the negative ion is a metal and the positive ion is the non-metal
 (D) both elements can be metals.
24. Which of the following molecules has the geometry of a distorted tetrahedron or seesaw?
 (A) PCl_3 (B) CHCl_3 (C) SiH_4 (D) TeCl_4
25. Arrange the following species in order of increasing stability: Li_2 , Li_2^+ , Li_2^- .
 (A) $\text{Li}_2^+ = \text{Li}_2 < \text{Li}_2^-$ (B) $\text{Li}_2 > \text{Li}_2^+ < \text{Li}_2^-$
 (C) $\text{Li}_2^- = \text{Li}_2^+ < \text{Li}_2$ (D) $\text{Li}_2^- < \text{Li}_2^+ < \text{Li}_2$

二、計算題（每題 10 分，共計 50 分）

1. 將一份 0.6760 克含有正二價的鋇離子且未知成份的化合物，溶解於水中並加入過量的硫酸鈉，如果沉澱出 0.4105 克的硫酸鋇，在一開始的未知成份化合物中含有多少百分比的鋇？(BaSO_4 : 233.4 ; Ba : 137.3)

2. 已知資料

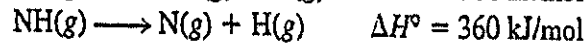
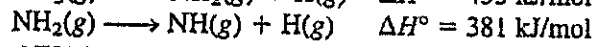
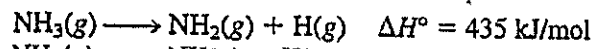


則下列反應中焓的變化為何？ $\text{S(斜方晶)} \rightarrow \text{S(單斜晶)}$

3. 一個類氫離子僅包含一個電子，在類氫離子中的電子被給予了下列式子的能量
 $E_n = -(2.18 \times 10^{-18} \text{ J}) \times Z^2 \times (1/n^2)$ 。假設 n 為主量子數，而 z 為此元素的原子序。以 kJ/mol 為單位計算正一價氦離子(He^+)的游離能。(He 的原子序為 2)



4. 依據下列資料，計算 N—H 鍵結的平均鍵能。



5. 氫氧燃料電池的反應為 $2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(l)$

已知此反應的 $\Delta H^\circ = -571.6 \text{ kJ}$, $\Delta S^\circ = -0.3264 \text{ kJ/K}$

請計算 95°C 下的 ΔG° 和 ΔE° (假設 ΔH° 和 ΔS° 與溫度無關)