

※ 注意：選擇題請於答案卷之「選擇題作答區」依序作答。

$$C = 3.00 \times 10^8 \text{ m/s}; h = 6.626 \times 10^{-34} \text{ J-s}; R_H = 1.096776 \times 10^7 \text{ m}^{-1}; F = 96500 \text{ C/mol}$$

$$\text{Gas constant: } R = 8.314 \text{ J/mol-K} = 0.0821 \text{ L-atm/mol-K}$$

Atomic mass:

$$H = 1.0 \text{ g/mol}, C = 12.0 \text{ g/mol}, O = 16.0 \text{ g/mol}, N = 14.0 \text{ g/mol}, He = 4 \text{ g/mol}, Mg = 24.3 \text{ g/mol}$$

I. 選擇題 (90%, 每題答案可能 1 至多個, 全部選對始得題分 3 分)

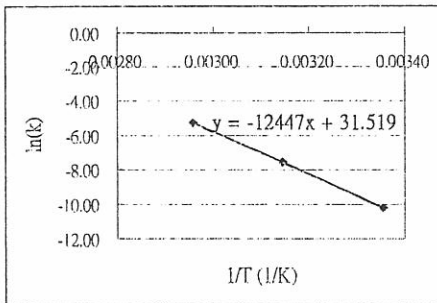
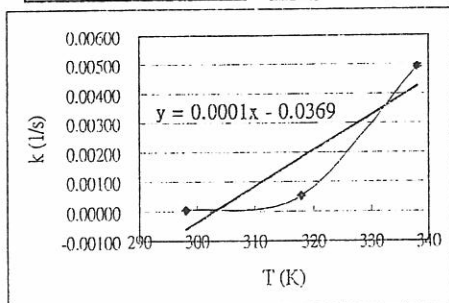
- Which of the following compound has the correct name?  
 (A)  $\text{Fe}(\text{NO}_3)_3$ , iron(III) nitrite (B)  $\text{P}_2\text{O}_5$ , diphosphorus pentoxide  
 (C)  $\text{Mg}(\text{H}_2\text{PO}_4)_2$ , magnesium dihydrogen phosphate (D)  $\text{CH}_3\text{CH}_2\text{OCH}_3$ , ethyl methyl ether
- Choose the one that has four significant figures in the answer:  
 (A)  $\frac{765.6 - 21.6}{0.1011 \times 298.15} \times 0.3045$  (B)  $12.56 - 10.41$  (C)  $11.11 \times 3.3$  (D)  $\log(2.0 \times 10^4)$
- A concentrated nitric acid is 67%  $\text{HNO}_3$  by mass and density 1.40 g/mL. Calculate the molarity (mol/L) of the acid.  
 (A) 22.2 M (B) 18.0 M (C) 14.9 M (D) 12.0 M
- By the reaction of 24.31 g of magnesium metal with 24.31 g of nitrogen gas, magnesium nitride can be formed. About the reaction, which of the following statement is correct? ( $Mg = 24.31$ ,  $N = 14.01$ )  
 (A) The balanced chemical reaction is:  $\text{Mg}(\text{s}) + \text{N}_2(\text{g}) \rightarrow \text{Mg}_3\text{N}_2(\text{s})$   
 (B) Nitrogen gas is the limiting reagent  
 (C) 48.62 g of magnesium nitride can be formed  
 (D)  $\Delta H_f^\circ(\text{Mg}_3\text{N}_2(\text{s})) = -461.1 \text{ kJ/mol}$ , so the described reaction is exothermic
- For one mole of the following gases at  $25^\circ\text{C}$  and 1 atm:  $\text{H}_2$ , He, and  $\text{CH}_4$ , choose the correct statement.  
 (A) The average kinetic energy:  $\text{H}_2 > \text{He} > \text{CH}_4$   
 (B) The average molecular speed:  $\text{H}_2 > \text{He} > \text{CH}_4$   
 (C) The effusion rate of the molecules:  $\text{H}_2 > \text{He} > \text{CH}_4$   
 (D) The density of the gas:  $\text{H}_2 > \text{He} > \text{CH}_4$
- Given the following two reactions  

$$2\text{NO} \rightarrow \text{N}_2 + \text{O}_2 \quad \Delta H = -180 \text{ kJ}$$

$$2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2 \quad \Delta H = -112 \text{ kJ}$$
 Calculate the enthalpy of the reaction (in kJ) of nitrogen gas with oxygen gas to produce nitrogen dioxide:  $\text{N}_2 + 2\text{O}_2 \rightarrow 2\text{NO}_2$   
 (A) -292 (B) -68 (C) 68 (D) 292
- When 2.00 mol of  $\text{SO}_2(\text{g})$  reacts completely with 1.00 mol of  $\text{O}_2(\text{g})$  to form 2.00 mol of  $\text{SO}_3(\text{g})$  at  $25^\circ\text{C}$  and constant pressure of 1.00 atm, 198 kJ of energy is released as heat.  
 (A)  $q = -198 \text{ kJ}$  (B)  $\Delta H = -198 \text{ kJ}$  (C)  $w = -198 \text{ kJ}$  (D)  $\Delta E$  (internal energy) =  $-198 \text{ kJ}$

8. The normal boiling point of methanol ( $\text{CH}_3\text{OH}$ ) is  $64.7^\circ\text{C}$ , and its molar enthalpy of vaporization is  $\Delta H_{\text{vap}} = +71.8 \text{ kJ/mol}$ .
- (A) The vapor pressure of methanol at  $64.7^\circ\text{C}$  is 760 torr.  
 (B) The vaporization of methanol is an endothermic process.  
 (C) The entropy of system increases during vaporization.  
 (D) Based on Trouton's rule,  $\Delta S_{\text{vap}}$  is about  $1.11 \text{ kJ/mol}\cdot\text{K}$ .
9. For an exothermic, spontaneous reaction:  $\text{Zn(s)} + \text{HCl(aq)} \rightarrow \text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$  at  $25^\circ\text{C}$ , which of the following must be true?
- (A)  $\Delta H^\circ < 0$       (B)  $\Delta S^\circ < 0$       (C)  $E^\circ_{\text{cell}} < 0$       (D)  $\Delta G^\circ < 0$
10. Indicate which of the following is a permissible set of quantum numbers?
- (A)  $n = 2, l = 2, m_l = +2, m_s = +1/2$       (B)  $n = 4, l = 2, m_l = -2, m_s = -1/2$   
 (C)  $n = 3, l = 1, m_l = +2, m_s = -1/2$       (D)  $n = 1, l = 0, m_l = 0, m_s = 0$
11. Which of the following is a polar molecule?  
 (A)  $\text{CF}_4$     (B)  $\text{SiF}_4$     (C)  $\text{SF}_4$     (D)  $\text{XeF}_4$
12. The decomposition of dimethyl ether,  $(\text{CH}_3)_2\text{O}$ , at  $510^\circ\text{C}$  is a first-order process with a rate constant of  $6.8 \times 10^{-4} \text{ s}^{-1}$ :  $(\text{CH}_3)_2\text{O(g)} \rightarrow \text{CH}_4\text{(g)} + \text{H}_2\text{(g)} + \text{CO(g)}$   
 If the initial pressure of  $(\text{CH}_3)_2\text{O}$  is 135 torr, how long will it take when the pressure of  $(\text{CH}_3)_2\text{O}$  drops to 51 torr?  
 (A) 17.9 s    (B) 1020 s    (C) 1430 s    (D)  $1.23 \times 10^5 \text{ s}$
13. The rate constant ( $k$ ) for the gas-phase decomposition of  $\text{N}_2\text{O}_5$ :  $\text{N}_2\text{O}_5 \rightarrow 2\text{NO}_2 + 1/2\text{O}_2$  has the following temperature dependence. Calculate the activation energy of the reaction.  
 (A) 0.831 J/mol    (B) 1020 J/mol    (C) 12447 J/mol    (D) 103 kJ/mol

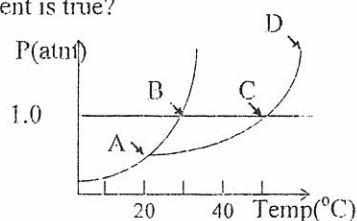
T (K)	k (1/s)	1/T	ln(k)
338	0.00490	0.00296	-5.32
318	0.00050	0.00314	-7.60
298	0.00004	0.00336	-10.26



14. In order to prepare a buffer with pH 7.4, which of the following pairs should you choose best?
- (A)  $\text{NaF}/\text{HF}$  ( $K_a = 6.8 \times 10^{-4}$ )      (B)  $\text{NaC}_6\text{H}_5\text{COO}/\text{C}_6\text{H}_5\text{COOH}$  ( $K_a = 6.5 \times 10^{-5}$ )  
 (C)  $\text{NaOCl}/\text{HOCl}$  ( $K_a = 3.0 \times 10^{-8}$ )      (D)  $\text{Na}_2\text{CO}_3/\text{NaHCO}_3$  ( $K_a = 5.6 \times 10^{-11}$ )

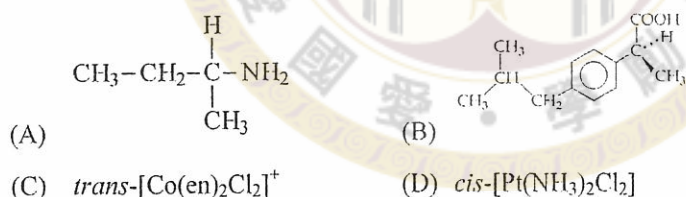


15. Given that  $\Delta G_f^\circ$  for  $\text{NH}_3 = -16.67 \text{ kJ/mol}$ , calculate the equilibrium constant for the following reaction at 298 K:  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g})$   
(A)  $1.20 \times 10^{-3}$  (B)  $8.36 \times 10^{-2}$  (C)  $8.36 \times 10^2$  (D)  $6.99 \times 10^5$
16. The dissociation energy of a carbon-bromine bond is typically about 210 kJ/mol. What is the maximum wavelength of photons that can cause C-Br bond dissociation?  
(A) 317 nm (B) 570 nm (C) 947 nm (D) 5261 nm
17. Use the following equations:  
 $\text{HAsO}_4^{2-}(\text{aq}) \rightleftharpoons \text{AsO}_4^{3-}(\text{aq}) + \text{H}^+(\text{aq}) \quad K_1 = 3.0 \times 10^{-13}$   
 $\text{HAsO}_4^{2-}(\text{aq}) + \text{H}^+(\text{aq}) \rightleftharpoons \text{H}_2\text{AsO}_4^-(\text{aq}) \quad K_2 = 1.8 \times 10^7$   
determine the equilibrium constant for the following reaction:  
 $\text{H}_2\text{AsO}_4^-(\text{aq}) \rightleftharpoons \text{AsO}_4^{3-}(\text{aq}) + 2\text{H}^+(\text{aq})$   
(A)  $1.7 \times 10^{-20}$  (B)  $1.8 \times 10^{-7}$  (C)  $5.6 \times 10^{-7}$  (D)  $5.4 \times 10^{-6}$
18. Consider the equilibrium:  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) \quad \Delta H = 58.0 \text{ kJ}$ , which of the following will shift the equilibrium to the right?  
(A) A catalyst is added to the system. (B)  $\text{N}_2$  is added at constant volume.  
(C) The volume is decreased. (D) The temperature is increased.
19. Which of the following radioactive decay shows the greatest penetrating power?  
(A)  $\alpha$ -decay (B)  $\beta$ -decay (C) positron emission (D)  $\gamma$ -decay
20. A radioactive element has a half-life of 1.0 hr. How many hours will it take for the number of atoms present to decay to 1/16th of the initial value?  
(A) 2.77 (B) 4 (C) 16 (D) 18
21. Which of the following solutions has the highest osmotic pressure at 25°C?  
(A) 0.2 M KBr (B) 0.2 M  $\text{CH}_3\text{COOH}$  (C) 0.2 M  $\text{Na}_2\text{SO}_4$  (D) 0.2 M glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$
22. A solution has a 1:4 mole ratio of pentane to hexane. The vapor pressures of the pure hydrocarbons at 20°C are 441 mmHg for pentane and 121 mmHg for hexane.  
(A) The mole fraction of pentane is 0.20.  
(B) The partial pressure of pentane is 88.2 mmHg.  
(C) The mole fraction of pentane in the vapor phase is 0.20.  
(D) The pentane is the more volatile component in the solution..
23. For the phase diagram of compound X, which of the following statement is true?  
(A) At 20°C and 1 atm, compound X exists as a liquid.  
(B) The normal melting point of compound X is about 50°C.  
(C) The critical point of compound X is point A  
(D) The melting point of the compound X increases with increasing pressure.

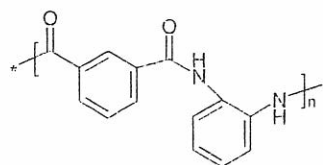
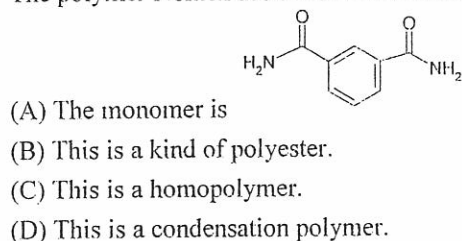


24. In the electrolysis of aqueous  $\text{NaCl}$ , how many liters of  $\text{Cl}_2(\text{g})$  (measured at STP) are generated by a current of 7.50 A for a period of 100 min?  
(A) 3.83 (B) 5.22 (C) 5.71 (D) 10.4

25. At 25°C,  $E^\circ_{\text{cell}} = 1.47 \text{ V}$  for the voltaic cell:  $\text{V(s)} \mid \text{V}^{2+} (1 \text{ M}) \parallel \text{Cu}^{2+} (1 \text{ M}) \mid \text{Cu(s)}$
- (A) V(s) is the anode.  
 (B) V(s) is the negative electrode.  
 (C) Electrons flow from V(s) to Cu(s).  
 (D) The cell potential ( $E_{\text{cell}}$ ) of the reaction is zero at equilibrium.
26. At 25°C, the value of  $E^\circ_{\text{cell}}$  for the reaction  $\text{Zn(s)} + \text{Pb}^{2+}(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{Pb(s)}$  is +0.66 V. What is  $E_{\text{cell}}$  for the reaction:  $\text{Zn(s)} + \text{Pb}^{2+}(0.010 \text{ M}) \rightarrow \text{Zn}^{2+}(0.10 \text{ M}) + \text{Pb(s)}$ ?
- (A) +0.60 V (B) +0.63 V (C) +0.66 V (D) +0.69 V
27. For the coordination compound,  $[\text{Rh}(\text{en})_2\text{Cl}_2]\text{NO}_3$
- (A) The oxidation number of the central metal is +3.  
 (B) The coordination number of the complex is 4.  
 (C) The geometry of the complex is square planar.  
 (D) The  $\text{NO}_3^-$  is one of the ligands.
28. Consider the complex ion  $[\text{CoF}_6]^{3-}$  and  $\text{F}^-$  is a weak-field ligand. Choose the correct statement.
- (A) The electron configuration of the neutral cobalt atom (Co) is  $[\text{Ar}]4s^23d^7$ .  
 (B) The electron configuration of the central metal cobalt ion in the complex is  $[\text{Ar}]4s^23d^4$ .  
 (C) The  $[\text{CoF}_6]^{3-}$  is a diamagnetic complex ion.  
 (D) It is a low-spin complex ion.
29. Which of the following exhibits optical isomerism?



30. The polymer Nomex has the structure shown on the right.



II. 計算問答題 (10%) ※ 本大題請於答案卷內之「非選擇題作答區」作答

1. Consider the  $\text{O}_2$  molecule, (a) Draw the molecular orbitals energy-level diagram. (b) Determine the bond order. (c) Indicate the magnetic property (diamagnetic or paramagnetic) of the molecule. (10%)