

本試題含單選題 30 題(90 分)，及一題敘述與計算題(10 分)，總分 100 分

元素週期表及常用的常數在最後一頁

I. 單選題 (選出一個最適當的答案) (每題 3 分) (答案直接填入“選擇題作答區”內)

- Which of the following properties is associated with the value of the m_l quantum number?
(A) the number of electrons in an orbital, (B) the size of an orbital, (C) the shape of an orbital, (D) the energy of an orbital, (E) the orientation in space of an orbital
- According to the Bohr model for the hydrogen atom, the energy necessary to excite an electron from $n = 2$ to $n = 3$ is _____ the energy necessary to excite an electron from $n = 4$ to $n = 5$.
(A) less than, (B) greater than, (C) equal to, (D) either equal to or greater than, (E) either less than or equal to
- The Schrodinger wave equation
(A) calculates the position and momentum of an electron at any given time.
(B) can be solved to determine the probability of finding an electron in a region of space.
(C) proves that energy is equal to mass times the speed of light squared.
(D) incorrectly predicts circular orbits of electrons around nuclei.
(E) is used to calculate the velocity of an electron.
- The _____ of a photon of light is proportional to its frequency and _____ proportional to its wavelength.
(A) amplitude, directly, inversely, (B) energy, inversely, directly, (C) energy, directly, inversely, (D) velocity, inversely, directly, (E) velocity, directly, inversely
- How many nodal planes exist for a $2p$ orbital?
(A) 0, (B) 1, (C) 2, (D) 3, (E) 4
- Ammonium carbonate $(\text{NH}_4)_2\text{CO}_3$ can decompose when heated enough, based on the following reaction:
 $(\text{NH}_4)_2\text{CO}_3(\text{s}) \rightarrow \text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{g}) + \text{CO}_2(\text{g})$
A mixture of $(\text{NH}_4)_2\text{CO}_3(\text{s})$ and $\text{Na}_2\text{CO}_3(\text{s})$ (stable towards heat) that weights 1.0 g is heated enough and a solid residue of 0.8 g is obtained. The weight percentage of Na_2CO_3 is then _____%.
(A) 60, (B) 70, (C) 80, (D) 90, (E) 50
- For each of the following molecules, use the Lewis structure to predict the polarity (polar or nonpolar) for each molecule. Which is not correct?
(A) CBr_4 , nonpolar, (B) ClO_2^- , polar, (C) ICl_3 , polar, (D) PF_3 , polar, (E) SO_3 , nonpolar
- Which of the following statements is (are) correct?
(a) The frequency of radiation increases as the wavelength increases.
(b) Electromagnetic radiation travels through a vacuum at a constant speed, regardless of wavelength.
(c) The glow from a fireplace, the energy within a microwave oven, and a foghorn blast are all forms of electromagnetic radiation.
(d) Visible light has higher frequencies than Infrared light.
(A) ab (B) bc (C) bd (D) ac
- Which of the following statement(s) about covalent bonding is or are correct?
(A) Molecules that have permanent dipoles are attracted to each other.
(B) Electrons are completely transferred from metal to nonmetal atom, and the resulting charged atoms are held together by electrostatic attractions.
(C) The fact that the boiling point of HF is higher than that of HCl is due to the formation of covalent bonding
(D) Electrons are shared between atoms of nonmetals to form stable compounds.

見背面

題號：41

題號：41

科目：普通化學(C)

共 5 頁之第 2 頁

10. If the rate law is $\text{Rate} = k[\text{A}]^2$ for a reaction $\text{A} + \text{B} \rightarrow \text{C}$, which of the following statement(s) about the reaction is or are correct?
 (a) The reaction is zero order in B
 (b) If $[\text{A}]$ is doubled, the reaction rate increased by a factor of 2
 (c) If a catalyst is added, the rate constant remains unchanged if the temperature is kept constant.
 (d) If $[\text{B}]$ is doubled, the rate constant remains unchanged if the temperature is kept constant.
 (A) ab (B) ac (C) bc (D) ad
11. If molecular iodine, $\text{I}_{2(\text{g})}$, dissociate into iodine atoms at 352°C with a first-order rate constant of 0.259 s^{-1} , calculate the half-life for this reaction?
 (A) 2.67 s^{-1} (B) 2.68 s^{-1} (C) 2.675 s^{-1} (D) 2.676 s^{-1}
12. Which of the following statement is incorrect:
 (A) The electron affinity of hydrogen is much closer to the values for the alkali elements than for the halogens.
 (B) Hydrogen has the smallest bonding atomic radius of any element that forms chemical compounds.
 (C) The ionization energy of hydrogen is closer to the values for the halogens than for the alkali metals.
 (D) The first ionization energy of the hydride ion (H^-) is higher than that of the hydrogen atom.
 (E) The electron affinity of a neutral hydrogen atom is higher than that of the hydride ion.
13. Which of the following statement is incorrect:
 (A) The octet rule is based on the fact that filling in all s and p valence electrons in a shell gives eight electrons.
 (B) The Si in SiH_4 does not follow the octet rule because H is in an unusual oxidation state.
 (C) Boron compounds are frequent exceptions to the octet rule because they have too few electrons surrounding the boron.
 (D) Compounds in which S is the central atom are frequent exceptions to the octet rule because they have too many electrons surrounding the sulfur.
14. Although I_3^- is known, F_3^- is not. Which statement is the most correct explanation?
 (A) I_2 is known but F_2 is not.
 (B) Fluorine is too electronegative to form anions.
 (C) Fluorine is too small to accommodate three nonbonding electron pairs and two bonding electron pairs.
 (D) Iodine is more likely to be electron-deficient.
 (E) Iodine has a larger electron affinity than fluorine.
15. A sample of N_2O_5 was placed in a container to allow the following reaction to occur:
 $2\text{N}_2\text{O}_{5(\text{g})} \rightarrow 4\text{NO}_{2(\text{g})} + \text{O}_{2(\text{g})}$
 The partial pressure of $\text{N}_2\text{O}_{5(\text{g})}$ was measured during the reaction and recorded in the table below.

Time (min)	$P_{\text{N}_2\text{O}_5}$ (atm)	$\ln(P_{\text{N}_2\text{O}_5})$	$1/P_{\text{N}_2\text{O}_5}$ (atm^{-1})
0	150	5.0	0.0067
100	75	4.3	0.013
200	38	3.6	0.027
300	19	2.9	0.053

Which of the following is true?

- (A) the reaction is a zero-order reaction (B) the reaction is a first-order reaction (C) the reaction is a second-order reaction (D) the overall reaction order is 3 (E) none of the above

接次頁

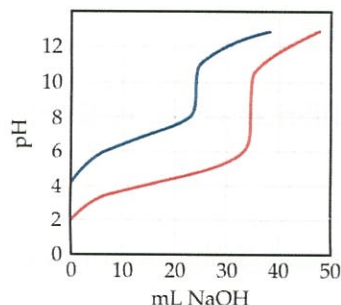
16. Which of the following processes are spontaneous?

- (a) alignment of iron filings in a magnetic field;
- (b) the dissolution of $\text{HCl}_{(g)}$ in water to form concentrated hydrochloric acid;
- (c) separating a mixture of N_2 and O_2 into two separate samples, one that is pure N_2 and one that is pure O_2 ;
- (d) the reaction of hydrogen gas with oxygen gas to form water vapor at room temperature;
- (e) the melting of ice cubes at -10°C and 1 atm pressure.

(A) abe (B) ac (C) bcd (D) abd (E) bde

17. Equal volumes of two acids are titrated with 0.10 M NaOH, resulting in the titration curves shown in the figure below. Which of the following descriptions is/are correct?

- (a) The red curve is more concentrated acid solution.
- (b) The blue curve is more concentrated acid solution.
- (c) The red curve acid has a larger K_a value.
- (d) The blue curve acid has a larger K_a value.



(A) ac (B) ad (C) bc (D) bd

18. Which of the following descriptions is/are correct?

- (a) CBr_4 is more volatile than CCl_4 .
- (b) CBr_4 has a higher boiling point than CCl_4 .
- (c) CBr_4 has stronger intermolecular forces than CCl_4 .
- (d) CBr_4 has a higher vapor pressure at the same temperature than CCl_4 .

(A) ab (B) ad (C) ac (D) bc

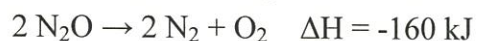
19. Acetic acid is a weak acid, and it spontaneously dissociates partially to form hydronium ions and aqueous anions in water. What do you know about the sign of the standard free-energy change (ΔG°) of this reaction?

- (A) $\Delta G^\circ < 0$ (B) $\Delta G^\circ > 0$ (C) $\Delta G^\circ = 0$ (D) The sign of ΔG° can not be determined

20. What is the standard free-energy change for the formation of 2 moles of $\text{NO}_{(g)}$ from $\text{N}_{2(g)}$ and $\text{O}_{2(g)}$ at 298 K? Given that $\Delta H^\circ = 180.7 \text{ kJ}$ and $\Delta S^\circ = 24.7 \text{ J/K}$ for this reaction.

- (A) -7.18 kJ (B) -7179.9 kJ (C) 173.3 kJ (D) 86.6 kJ (E) 156.0 kJ

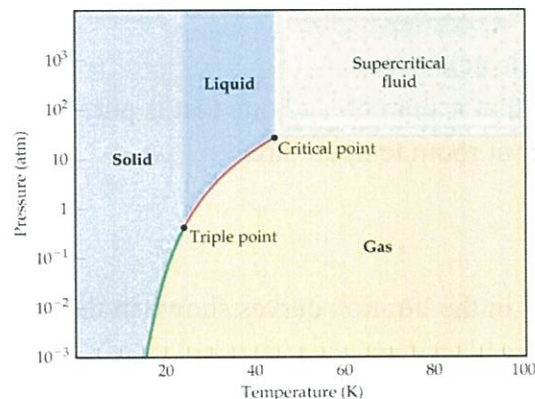
21. Given



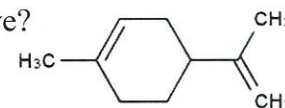
What is the ΔH of $\text{N}_2\text{O} + \text{NO}_2 \rightarrow 3 \text{NO}$?

- (A) 175 (B) 75 (C) 95 (D) -75 (E) -175 KJ

22. This is the phase diagram of neon. What is the normal (at 1 atm) boiling point of neon?



- (A) 0 K (B) 50 K (C) 30 K (D) 100K (E) room temperature
23. The average osmotic pressure of blood is 7.7 atm at 25 °C. What molarity of glucose ($C_6H_{12}O_6$) will be isotonic with blood? ($R = 0.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$)
(A) 3 M (B) 1.2 M (C) 0.31 M (D) 155 mM (E) 55 mM
24. The oxidation of glucose, $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6 H_2O$, has a very large equilibrium constant, $K \gg 1$. Why is glucose stable at room temperature?
(A) $\Delta H < 0$ (B) $\Delta G > 0$ (C) $\Delta G < 0$ (D) $\Delta S > 0$ (E) the activation energy is too high.
25. You are asked to prepare a pH = 4.00 buffer from 1.50 L of 0.0200 M of Benzoic acid C_6H_5COOH ($pK_a = 5.00$). How many moles of sodium benzoate C_6H_5COONa do you need to add?
(A) 0.10 (B) 0.015 (C) 0.64 (D) 0.0030 (E) 0.040
26. For a particular reaction, $\Delta H = -32 \text{ kJ}$, and $\Delta S = -98 \text{ J/K}$. Assume that ΔH and ΔS do not vary with temperature. At what temperature will the reaction have $\Delta G = 0$?
(A) 304 K (B) 326K (C) 355 K (D) 520 K (E) ΔG is always negative
27. This molecule, limonene, has the smell of lemons. How many chiral centers does it have?
(A) 4 (B) 3 (C) 2 (D) 1 (E) 0



28. A voltaic cell based on the reaction
 $2 \text{Eu}^{2+}_{(aq)} + \text{Ni}^{2+}_{(aq)} \rightarrow 2 \text{Eu}^{3+}_{(aq)} + \text{Ni}_{(s)}$
 generates $E^\circ_{\text{cell}} = 0.07 \text{ V}$. Given that the standard reduction potential of Ni^{2+} is -0.28 V , what is the standard oxidation potential of Eu^{2+} ?
 (A) -0.21 V (B) 0.21 V (C) -0.35 V (D) 0.35 V (E) 0.07 V
29. If the potential of a Zn-H⁺ cell is 0.45 V at 25 °C when $[\text{Zn}^{2+}] = 1.0 \text{ M}$ and $P_{\text{H}_2} = 1.0 \text{ atm}$, what is the pH of the cathode solution? ($E^\circ_{\text{red}} = -0.76 \text{ V}$ for Zn^{2+})
 (A) 1.0 (B) 2.6 (C) 5.2 (D) 8.8 (E) 11.4
30. The air bags that provide protection in cars expand in the event of an accident. From the viewpoint of the reactants as the system, what do you expect for the signs of q and w in this process?
 (A) $w > 0$, $q < 0$ (B) $w < 0$, $q < 0$ (C) $w < 0$, $q > 0$ (D) $w > 0$, $q > 0$ (E) $w < 0$, $q = 0$

II. 敘述與計算題 (共 10 分) (注意：請於答案卷內之「非選擇題作答區」作答，並應註明作答之題號。)

1. Consider the reversible reaction
- $2\text{NO}_{2(g)} \rightleftharpoons \text{N}_2\text{O}_{4(g)}$
- .

	ΔH_f° (kJ/mole)	S° (J/mole-K)
$\text{NO}_{2(g)}$	33.84	240.45
$\text{N}_2\text{O}_{4(g)}$	9.66	304.3

 (Need to write **calculation process** and **units!**)

- Calculate the change in the standard enthalpy of the system, ΔH° , at 298 K. (2pts)
- Calculate the change in the standard entropy of the system, ΔS° , at 298 K. (2pts)
- Calculate the change in the standard free energy of the system, ΔG° at 298 K. (2pts)
- Calculate the equilibrium constant K at 298K. (2pts)
- Calculate ΔG at 298 K if the partial pressures of $\text{NO}_{2(g)}$ and $\text{N}_2\text{O}_{4(g)}$ are 0.40 atm and 1.60 atm, respectively. (2pts)

*****元素週期表及常用的常數*****
Periodic table:

1 H 1.00794																	2 He 4.002602
3 Li 6.941	4 Be 9.012182											5 B 10.811	6 C 12.0107	7 N 14.00674	8 O 15.9994	9 F 18.9984032	10 Ne 20.1797
11 Na 22.989770	12 Mg 24.3050											13 Al 26.981538	14 Si 28.0855	15 P 30.973761	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.955910	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.938049	26 Fe 55.845	27 Co 58.933200	28 Ni 58.6934	29 Cu 63.545	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.92160	34 Se 78.96	35 Br 79.504	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.90585	40 Zr 91.224	41 Nb 92.90638	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.90550	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.90447	54 Xe 131.29
55 Cs 132.90545	56 Ba 137.327	57 La 138.9055	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.227	78 Pt 195.078	79 Au 196.96655	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.98038	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (266)	110 (269)	111 (272)	112 (277)		114 (289)		116 (289)		118 (293)

Physical constants:

$$c=3.0 \times 10^8 \text{ m/s}, m_e=9.1 \times 10^{-31} \text{ kg}, h=6.626 \times 10^{-34} \text{ Js}, 1\text{eV}=1.60 \times 10^{-19} \text{ J}, R=8.314 \text{ J/K mol}, N_A=6.02 \times 10^{23}, F=96500 \text{ C/mol}$$

Thermodynamic relations:

$$E=TS-PV, H=E+PV, G=H-TS$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

Standard Reduction Potentials in Water at 25 °C

E_{red}° (V)	Reduction Half-Reaction
+2.87	$\text{F}_2(g) + 2 e^- \longrightarrow 2 \text{F}^-(aq)$
+1.51	$\text{MnO}_4^-(aq) + 8 \text{H}^+(aq) + 5 e^- \longrightarrow \text{Mn}^{2+}(aq) + 4 \text{H}_2\text{O}(l)$
+1.36	$\text{Cl}_2(g) + 2 e^- \longrightarrow 2 \text{Cl}^-(aq)$
+1.33	$\text{Cr}_2\text{O}_7^{2-}(aq) + 14 \text{H}^+(aq) + 6 e^- \longrightarrow 2 \text{Cr}^{3+}(aq) + 7 \text{H}_2\text{O}(l)$
+1.23	$\text{O}_2(g) + 4 \text{H}^+(aq) + 4 e^- \longrightarrow 2 \text{H}_2\text{O}(l)$
+1.06	$\text{Br}_2(l) + 2 e^- \longrightarrow 2 \text{Br}^-(aq)$
+0.96	$\text{NO}_3^-(aq) + 4 \text{H}^+(aq) + 3 e^- \longrightarrow \text{NO}(g) + 2 \text{H}_2\text{O}(l)$
+0.80	$\text{Ag}^+(aq) + e^- \longrightarrow \text{Ag}(s)$
+0.77	$\text{Fe}^{3+}(aq) + e^- \longrightarrow \text{Fe}^{2+}(aq)$
+0.68	$\text{O}_2(g) + 2 \text{H}^+(aq) + 2 e^- \longrightarrow \text{H}_2\text{O}_2(aq)$

試題隨卷繳回