| 1 1A | | | | | | | | | | | | 13 3A | 14 4A | 15 5A | 16 6A | 17 7A | 18 8A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H 1.008 | 2 2A | | | | | | | | | | | | | | | | 2 He 4.003 |
| 3 Li 6.941 | 4 Be 9.012 | | | | | | | | | | | 5 B 10.81 | 6 C 12.01 | 7 N 14.01 | 8 O 16.00 | 9 F 19.00 | 10 Ne 20.18 |
| 11 Na 22.99 | 12 Mg 24.31 | 3 3B | 4 4B | 5 5B | 6 6B | 7 7B | 8 | 9 8B | 10 | 11 1B | 12 2B | 13 Al 26.98 | 14 Si 28.09 | 15 P 30.97 | 16 S 32.07 | 17 Cl 35.45 | 18 Ar 39.95 |
| 19 K 39.10 | 20 Ca 40.08 | 21 Sc 44.96 | 22 Ti 47.88 | 23 V 50.94 | 24 Cr 52.00 | 25 Mn 54.94 | 26 Fe 55.85 | 27 Co 58.93 | 28 Ni 58.69 | 29 Cu 63.55 | 30 Zn 65.39 | 31 Ga 69.72 | 32 Ge 72.59 | 33 As 74.92 | 34 Se 78.96 | 35 Br 79.90 | 36 Kr 83.80 |
| 37 Rb 85.47 | 38 Sr 87.62 | 39 Y 88.91 | 40 Zr 91.22 | 41 Nb 92.91 | 42 Mo 95.94 | 43 Tc (98) | 44 Ru 101.1 | 45 Rh 102.9 | 46 Pd 106.4 | 47 Ag 107.9 | 48 Cd 112.4 | 49 In 114.8 | 50 Sn 118.7 | 51 Sb 121.8 | 52 Te 127.6 | 53 I 126.9 | 54 Xe 131.3 |
| 55 Cs 132.9 | 56 Ba 137.3 | 57 La 138.9 | 72 Hf 178.5 | 73 Ta 180.9 | 74 W 183.9 | 75 Re 186.2 | 76 Os 190.2 | 77 Ir 192.2 | 78 Pt 195.1 | 79 Au 197.0 | 80 Hg 200.6 | 81 Tl 204.4 | 82 Pb 207.2 | 83 Bi 209.0 | 84 Po (210) | 85 At (210) | 86 Rn (222) |
| 87 Fr (223) | 88 Ra (226) | 89 Ac (227) | 104 Rf (257) | 105 Db (260) | 106 Sg (263) | 107 Bh (262) | 108 Hs (265) | 109 Mt (266) | 110 | 111 | 112 | | | | | | |

本試題含單選題 25 題(75 分), 及敘述題(25 分), 總分 100 分

**(A).** 單一選擇題 (選出一個最適當的答案)：每題答對 3 分，答錯倒扣 1 分，答案直接填入"選擇題作答區"內。(填寫多於一個選項，該題不予計分)

**1.** Naturally occurring bromine consists of two isotopes: bromine-79 and bromine-81. The atomic mass for bromine is approximately 80. What are reasonable estimates of the relative percentages of bromine-79 and bromine-81 respectively?
A) 90, 10 B) 10, 90 C) 50, 50 D) 75, 25 E) 25, 75

**2.** What is the oxidation number of chromium in $H_2CrO_4$?
A) (-1) B) +1 C) +2 D) +7 E) +6

**3.** The assumptions of the kinetic-molecular theory are most likely to be correct under what conditions?
A) high temperature and high pressure
B) low temperature and low pressure
C) low temperature and high pressure
D) high temperature and low pressure
E) always correct

**4.** Given the following data, what is the enthalpy of the reaction at 25°C shown below?
($\Delta H^\circ_{f,\,C_2H_2} = 226.7$ kJ/mol ; $\Delta H^\circ_{f,\,C_2H_4} = 52.26$ kJ/mol )

$$C_2H_{2\,(g)} + H_{2\,(g)} \longrightarrow C_2H_{4\,(g)}$$

A) 87.2 kJ/mol
B) 174.4 kJ/mol
C) -174.4 kJ/mol
D) 279.0 kJ/mol
E) More information is needed to answer this question.

**5.** Calculate the wavelength, in nanometers, of an x-ray that has frequency of $5.15 \times 10^{16}\ s^{-1}$.
A) 5.83 B) 17.2 C) 583 D) $1.72 \times 10^8$ E) 0.172

**6.** Which of the following electron transitions will produce a photon of the shortest wavelength in the Bohr hydrogen atom?
A) $n = 4$ to $n = 3$ B) $n = 3$ to $n = 4$ C) $n = 3$ to $n = 1$
D) $n = 4$ to $n = 1$ E) $n = 2$ to $n = 1$

**7.** Which of the following sets is not an acceptable set of quantum numbers.
A) $n = 2,\ l = 1,\ m_l = +1$ B) $n = 2,\ l = 1,\ m_l = (-1)$
C) $n = 3,\ l = 1,\ m_l = (-3)$ D) $n = 1,\ l = 0,\ m_l = 0$
E) $n = 7,\ l = 3,\ m_l = +3$

**8.** Which of the following isoelectronic species would have the largest radius?
A) $N^{3-}$ B) $Na^+$ C) $Mg^{2+}$ D) $F^-$ E) $O^{2-}$

**9.** Given the following successive ionization energies ( $I_x$), predict which element it corresponds to.

| | $I_1$ | $I_2$ | $I_3$ | $I_4$ |
|---|---|---|---|---|
| ( MJ/mol) | 0.80 | 2.43 | 3.66 | 25.02 |

A) Be B) N C) B D) C E) Li

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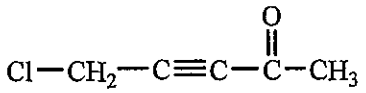
**10.** How many valence electrons are shown in the Lewis structure of $NO_3^-$ ?
A) 11 B) 15 C) 22 D) 23 E) 24

**11.** Which one of the following species follows the octet rule?
A) NO B) $CO_2$ C) $NO_2$ D) $BF_3$ E) $SF_6$

**12.** How many of the following compounds can exist as cis-trans isomers?
$CH_3CH{=}CHCl$ $CH_2{=}CHCH_3$ $CHF{=}CHCl$
$CH_3CH{=}CHCH_3$ $CH_3C{\equiv}CCH_3$
A) 0 B) 1 C) 2 D) 3 E) 4

**13.** How many σ bonds are there in the following structure?



A) 4 B) 6 C) 8 D) 11 E) 14

**14.** How many of the following variables will cause a change in the vapor pressure above a liquid in a closed container?
amount of the liquid
surface area of the liquid
volume of the container
pressure of the container
temperature of the liquid
A) 1 B) 3 C) 2 D) 0 E) 4

**15.** Which statement is incorrect?
A) Polar molecules always have higher boiling points than nonpolar molecules.
B) Dispersion forces are present in all molecular substances.
C) The polarizability of elongated molecules is greater than that of compact, more spherical molecules.
D) Hydrogen bonding leads to the strongest intermolecular forces.
E) The greater the dipole moment, the stronger the dipole-dipole forces.

**16.** A mixture is prepared with [CO] = 0.035, $[Cl_2]$ = 0.015, and $[COCl_2]$ = 0.95. It is known that $K_c$ for the equilibrium $CO(g) + Cl_2(g) \leftrightarrow COCl_2(g)$ is $1.2 \times 10^3$ at 400°C. Predict what will happen.
A) The reaction occurs in the forward direction.
B) The reaction occurs in the reverse direction.
C) The reaction is at equilibrium so no net reaction occurs.
D) It is impossible to predict without more information.
E) None of the above

**17.** If 125 mL of 0.015 M $BaCl_2$ is mixed with 75 mL of 0.0010 M $Na_2SO_4$, will a precipitate form? ( Ksp, $BaSO_4 = 1.1 \times 10^{-10}$ )
A) Yes, because $Q > K_{sp}$. B) No, because $Q = K_{sp}$. C) No, because $Q < K_{sp}$.
D) Yes, because $Q < K_{sp}$. E) No, because $Q > K_{sp}$.

**18.** The following reaction is endothermic: $2\,SO_3(g) \rightarrow 2\,SO_2(g) + O_2(g)$. The reaction is
A) non-spontaneous at all temperatures.
B) spontaneous at low temperatures.
C) spontaneous at high temperatures.
D) spontaneous at all temperatures.
E) None of the above

**19.** Which of the following must be true in order for a reaction to be at equilibrium?
A) $K_{eq} = 0$ B) $\Delta H = 0$ C) $\Delta S = 0$ D) $\Delta G = 0$ E) T = 298 K

**20.** Which of the following atoms would be most reactive with water at room temperature?
A) K B) Ba C) Mg D) Ca E) Li

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**21.** Write the net equation for the redox reaction that occurs in the voltaic cell.

$$Cu(s) \mid Cu^{2+}(aq) \parallel Ag^{+}(aq) \mid Ag(s)$$

A) $2\,Ag^{+}(aq) + Ag(s) \rightarrow Cu(s) + Cu^{2+}(aq)$
B) $Cu^{2+}(aq) + 2\,Ag(s) \rightarrow Cu(s) + 2\,Ag^{+}(aq)$
C) $Cu(s) + 2\,Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2\,Ag(s)$
D) $Cu(s) + Cu^{2+}(aq) \rightarrow 2\,Ag^{+}(aq) + Ag(s)$
E) None of the above

**22.** The best explanation for the fact that oxygen forms only $OF_2$ with fluorine, while sulfur forms $SF_2$, $SF_4$, and $SF_6$, is that

A) oxygen is more electronegative than sulfur.
B) sulfur is less electronegative than oxygen.
C) oxygen is smaller than sulfur.
D) sulfur has d orbitals available for bonding.
E) only oxygen forms hydrogen bonds.

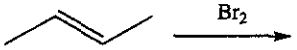
**23.** What is the coordination number and oxidation state of the central atom in $[CoCl(NH_3)_4]^{2+}$?

A) 6 , +2 B) 5 , +3 C) 4 , +3 D) 1 , +2 E) 5 , +2

**24.** How many unpaired electrons would you expect for the tetrahedral complex, $[FeBr_4]^{-}$, where $Br^{-}$ is a weak field ligand ?

A) 5 B) 2 C) 4 D) 1 E) 0

**25.** *Indicate the organic product of the following reaction.*




A) 1,2-dibromobutane
B) 1-bromoethylethane
C) 2,2-dibromobutane
D) 2-methylpropane
E) 2,3-dibromobutane

**(B). 敘述題 (共 25 分)**：請利用適當的文字，圖表或公式解釋及描述下列問題。

**1.** For a particle in a box of nanometer size, the energy level is quantized as $\Delta E = E_{n+1} - E_n = \frac{(2n+1)h^2}{8mL^2}$.

Use this information to quantitatively explain the following observations.

(1a). Larger sized quantum dots emitted lights with longer wavelength. (5 pts)
(1b). Heavy particles have larger entropy than lighter particles of the same size of box at the same temperature. (5 pts)

**2.** Experiments have shown that the homonuclear $O_2$ is paramagnetic (i.e. have un-paired electrons).
(2a). Draw the energy diagram of molecular orbitals in $O_2$ with the electrons filled, and use them to explain why $O_2$ is paramagnetic. (6 pts)
(2b). Arrange $O_2^{2-}$, $O_2^{-}$, $O_2$ three molecules in the order of increasing bond length (from small to large). (3 pts)

**3.** Silicon dioxide (silica, $SiO_2$) is one of the most commonly substances used in electronics. Si and C both belong to 4A group in the periodic table. Is the structure of $SiO_2$ similar to that of $CO_2$? Why or Why not. Predict the bond angle of O-Si-O, and the structure of $SiO_2$. (6 pts)

試題隨卷繳回