# 1032_3rd Exam_1040527(A)

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.
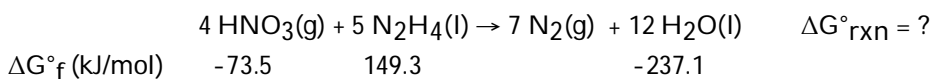
1) The _____ Law of Thermodynamics states the energy is conserved in chemical processes.
   A) Zero                B) First              C) Second            D) Third             E) Fourth
   Answer: B

2) Which is necessarily true for a spontaneous process?
   A) $\Delta S_{universe} > 0$
   B) $\Delta E > 0$
   C) $q = 0$
   D) $\Delta H < 0$
   E) $\Delta S°_{system} > 0$
   Answer: A

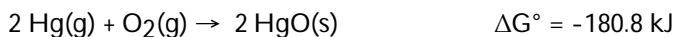3) Calculate the $\Delta G°_{rxn}$ using the following information.

$$4\ HNO_3(g) + 5\ N_2H_4(l) \rightarrow 7\ N_2(g) + 12\ H_2O(l) \qquad \Delta G°_{rxn} = ?$$

| $\Delta G°_f$ (kJ/mol) | -73.5 | 149.3 | | -237.1 |
|---|---|---|---|---|

   A) +954.7 kJ
   B) +2.845 x $10^3$ kJ
   C) -954.7 kJ
   D) -3.298 x $10^3$ kJ
   E) -312.9 kJ
   Answer: D

4) Calculate $\Delta G_{rxn}$ at 298 K under the conditions shown below for the following reaction.
   ($R = 8.314\ J \cdot mol^{-1} \cdot K^{-1}$)

$$2\ Hg(g) + O_2(g) \rightarrow 2\ HgO(s) \qquad \Delta G° = -180.8\ kJ$$

   $P(Hg) = 0.025$ atm, $P(O_2) = 0.037$ atm

   A) -164 kJ            B) -154.4 kJ          C) -26.5 kJ          D) +207 kJ           E) +60.7 kJ
   Answer: B

5) For an exothermic reaction to be nonspontaneous at high temperatures, the enthalpy must be _____ while
   the entropy is _____.
   A) positive, negative
   B) a relatively small negative value, also negative
   C) positive, also positive
   D) a relatively large negative value, positive
   E) a very large negative value, also negative
   Answer: B

6) Which statement is true for the freezing of liquid water below 0 °C?
   A) $\triangle H$ is positive; $\triangle S$ is positive; $\triangle G$ is positive      B) $\triangle H$ is positive; $\triangle S$ is negative; $\triangle G$ is negative
   C) $\triangle H$ is positive; $\triangle S$ is negative; $\triangle G$ is positive      D) $\triangle H$ is negative; $\triangle S$ is negative; $\triangle G$ is negative

   Answer: D

7) Above what temperature, in °C, will the following reaction become spontaneous?  Assume enthalpy and entropy are not temperature dependent.

$$CCl_{4(g)} \rightarrow C_{(s,\ graphite)} + 2\ Cl_{2(g)} \quad \Delta H = +95.7\ kJ;\ \Delta S = +142.2\ J/K$$
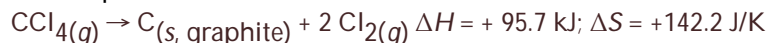
   A) 150
   B) 400
   C) 25
   D) This reaction is nonspontaneous at all temperatures.
   E) This reaction is spontaneous at all temperatures.

   Answer: B

8) Place the following in order of increasing entropy at 298 K.

   Ne      Xe      He      Ar      Kr

   A) He < Ne < Ar < Kr < Xe
   B) Ar < He < Ar < Ne < Kr
   C) He < Kr < Ne < Ar < Xe
   D) Ar < Ne < Xe < Kr < He
   E) Xe < Kr < Ar < Ne < He

   Answer: A

9) Which reaction is most likely to have a positive $\triangle S_{sys}$ ?
   A) $CO(g) + Cl_2(g) \rightarrow COCl_2(g)$                    B) $SiO_2(s) + 3\ C(s) \rightarrow SiC(s) + 2\ CO(g)$
   C) $3\ NO_2(g) + H_2O(l) \rightarrow 2\ HNO_3(l) + NO(g)$      D) $6\ CO_2(g) + 6\ H_2O(g) \rightarrow C_6H_{12}O_6(s) + 6\ O_2(g)$

   Answer: B

10) The molar heat of vaporization for ethanol is 37.4 kJ/mol.  If the boiling point of ethanol is 78.0°C, calculate $\Delta S$ for the vaporization of 0.500 mol ethanol, in J/K.
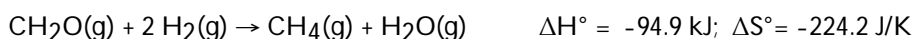    A) 0.0535          B) 479          C) 53.5          D) 0.240          E) 107

    Answer: C

11) Which of the following reactions will have the largest equilibrium constant (K) at 298 K?
    A) $Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3\ CO_2(g)$      $\Delta G° = -28.0\ kJ$
    B) $2\ Hg(g) + O_2(g) \rightarrow 2\ HgO(s)$                      $\Delta G° = -180.8\ kJ$
    C) $3\ O_2(g) \rightarrow 2\ O_3(g)$                             $\Delta G° = +326\ kJ$
    D) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$                      $\Delta G° = +131.1\ kJ$

    Answer: B

12) Determine the equilibrium constant for the following reaction at 549 K. ($R = 8.314\ J \cdot mol^{-1} \cdot K^{-1}$)

$$CH_2O(g) + 2\ H_2(g) \rightarrow CH_4(g) + H_2O(g) \quad \Delta H° = -94.9\ kJ;\ \Delta S° = -224.2\ J/K$$

    A) $1.07 \times 10^9$          B) $1.94 \times 10^{-12}$          C) 481          D) $2.08 \times 10^{-3}$          E) $9.35 \times 10^{-10}$
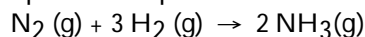
    Answer: D

13) For a certain reaction, the standard free energy change is -80.0 kJ at 300 K and -40.0 kJ at 600 K. What is $\Delta H$ for this reaction, in kJ?

    A) +40                B) -80                C) -40                D) +80                E) -120

Answer: E

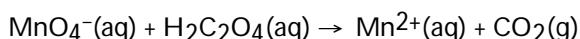14) Assume enthalpy and entropy are not temperature dependent. For the reaction:
$$N_2 \text{ (g)} + 3\,H_2 \text{ (g)} \rightarrow 2\,NH_3\text{(g)}$$

$\Delta H° = -92.2$ kJ and $K_p = 6.8 \times 10^5$ at 25°C. Calculate the value of $K_p$ at 225°C.

$(R = 8.314$ J·mol$^{-1}$·K$^{-1})$

    A) $7.8 \times 10^{-10}$       B) $2.1 \times 10^{12}$       C) $6.8 \times 10^5$       D) $1.8 \times 10^2$       E) $2.2 \times 10^{-1}$

Answer: E

15) What element is being oxidized in the following redox reaction?

$$MnO_4^-\text{(aq)} + H_2C_2O_4\text{(aq)} \rightarrow Mn^{2+}\text{(aq)} + CO_2\text{(g)}$$

    A) H                B) O                C) C                D) Mn
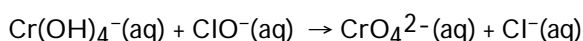
Answer: C

16) Which of the following half-reactions is not correct?

    A) $Mg \rightarrow Mg^{2+} + 2e^-$
    B) $Cu^+ + e^- \rightarrow Cu$
    C) $Pb^{2+} + e^- \rightarrow Pb^{3+}$
    D) $Fe^{3+} + 2e^- \rightarrow Fe^+$
    E) $Ag \rightarrow Ag^+ + e^-$

Answer: C
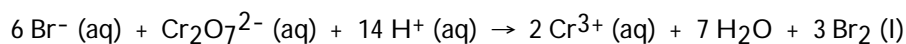
17) Balance the following redox reaction if it occurs in basic solution. What are the coefficients in front of $Cr(OH)_4^-$ and $ClO^-$ in the balanced reaction?

$$Cr(OH)_4^-\text{(aq)} + ClO^-\text{(aq)} \rightarrow CrO_4^{2-}\text{(aq)} + Cl^-\text{(aq)}$$

    A) $Cr(OH)_4^- = 2$, $ClO^- = 3$
    B) $Cr(OH)_4^- = 1$, $ClO^- = 1$
    C) $Cr(OH)_4^- = 2$, $ClO^- = 6$
    D) $Cr(OH)_4^- = 6$, $ClO^- = 5$
    E) $Cr(OH)_4^- = 1$, $ClO^- = 2$

Answer: A

18) How many electrons are transferred in the following reaction?

$$6\,Br^- \text{ (aq)} + Cr_2O_7^{2-} \text{ (aq)} + 14\,H^+ \text{ (aq)} \rightarrow 2\,Cr^{3+} \text{ (aq)} + 7\,H_2O + 3\,Br_2 \text{ (l)}$$

    A) 1                B) 2                C) 3                D) 6                E) 14

Answer: D

19) Identify the location of reduction in an electrochemical cell.
    A) the cathode             B) the anode             C) the salt bridge          D) the electrolyte

Answer: A

### Table A    Selected Standard Electrode Potentials at 25°C

| Reaction | $E°$, V |
|---|---|
| $Mg^{2+}$ (aq) + 2 e⁻ → Mg (s) | -2.356 |
| $Fe^{2+}$ (aq) + 2 e⁻ → Fe (s) | -0.440 |
| $Pb^{2+}$ (aq) + 2 e⁻ → Pb (s) | -0.125 |
| 2 $H^+$ (aq) + 2 e⁻ → $H_2$ (g) | 0.0 |
| $Cu^{2+}$ (aq) + 2 e⁻ → Cu (s) | +0.337 |
| $I_2$ (s) + 2 e⁻ → 2 I⁻ (s) | +0.535 |
| $Fe^{3+}$ (aq) + 2 e⁻ → $Fe^{2+}$ (aq) | +0.771 |
| $Ag^+$ (aq) + e⁻ → Ag (s) | +0.800 |
| $O_2$ (g) + 4 $H^+$ (aq) + 2 e⁻ → 2 $H_2O$ | +1.229 |
| $Cl_2$ (g) + 2 e⁻ → 2 Cl⁻ (aq) | +1.358 |
| $F_2$ (g) + 2 e⁻ → 2 F⁻ (aq) | +2.866 |

20) (Refer to Table A) Which of the following is the best oxidizing agent?
    A) $Mg^{2+}$             B) $Fe^{3+}$           C) $Cu^{2+}$           D) F⁻           E) $Cl_2$
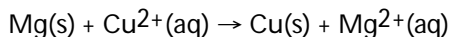
Answer: E

21) (Refer to Table A) Calculate the standard cell potential for the following balanced reaction occurring in an electrochemical cell at 25°C.

       Mg(s) + $Cu^{2+}$(aq) → Cu(s) + $Mg^{2+}$(aq)
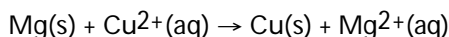
    A) -2.693 V         B) -2.019 V         C) +2.019 V         D) +1.362 V         E) +2.693 V
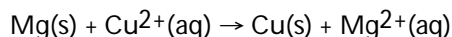
Answer: E

22) (Refer to Table A) Calculate $\Delta G°$ for the following balanced redox reaction at 25°C. (1 F = 96485 C/mol e⁻, 1 V = 1 J/C)

       Mg(s) + $Cu^{2+}$(aq) → Cu(s) + $Mg^{2+}$(aq)

    A) +520 kJ         B) -2.3 kJ         C) -78 kJ         D) +2.3 kJ         E) -520 kJ

Answer: E

23) (Refer to Table A) Calculate the equilibrium constant (K) for the following balanced redox reaction at 25°C.

       Mg(s) + $Cu^{2+}$(aq) → Cu(s) + $Mg^{2+}$(aq)

    A) $9.54 \times 10^{-90}$     B) $8.9 \times 10^{18}$     C) $9.54 \times 10^{90}$     D) $8.9 \times 10^{-18}$     E) $1.7 \times 10^{29}$

Answer: C

24) (Refer to Table A) Calculate the cell potential for the following reaction that takes place in an electrochemical cell at 25°C.

$$Mg(s) \mid Mg^{2+}(aq, 2.74 \text{ M}) \parallel Cu^{2+}(aq, 0.0033 \text{ M}) \mid Cu(s)$$

A) +3.71 V          B) +2.61 V          C) -2.61 V          D) +2.12 V          E) -2.12 V

Answer: B

25) Which of the following reactions would have the smallest value of K at 298 K? (Assume the number of electron transfer for those reactions are same.)

A) $A + B \rightarrow C$;  $E°_{cell}$ = +1.22 V                    B) $A + 2 B \rightarrow C$;  $E°_{cell}$ = +0.98 V

C) $A + B \rightarrow 3 C$;  $E°_{cell}$ = +0.15 V                    D) $A + B \rightarrow 2 C$;  $E°_{cell}$ = -0.030 V

Answer: D

26) Identify the components of a fuel cell.
   A) lithium ion
   B) nickel-metal hydride
   C) hydrogen-oxygen
   D) nickel-cadmium
   E) zinc-manganese

Answer: C

27) Describe how water can be a good conductor of current.
   A) chill the water
   B) vaporize the water
   C) heat the water
   D) use pure water
   E) add salt

Answer: E

28) What mass of aluminum can be plated onto an object in 755 minutes at 5.80 A of current?
   (1 F = 96485 C/mol e$^-$,  1 A = 1 C/s, AW of Al = 26.98)
   A) 73.5 g          B) 147 g          C) 24.5 g          D) 8.17 g          E) 220. g

Answer: C

29) What is the coordination number and oxidation state of the central atom in $[Fe(CN)_6]^{4-}$?
   A) 6      +2          B) 0      +3          C) 3      +2          D) 3      -4          E) 6      -4

Answer: A

30) Which statement regarding ligands is correct?
   A) Positive ions make good ligands.
   B) All ligands are negative ions.
   C) Only one atom of the ligand can bond to the metal.
   D) The atom bonding to the metal is positively polarized.
   E) All ligands are Lewis bases.

Answer: E

31) Which of the following elements would have five unpaired electrons in atomic form?
   A) Mn          B) Fe          C) Cr          D) Co          E) V

Answer: A

32) What is the ground state electron configuration of $Ni^{2+}$?

    A) [Ar] $4s^2 4d^6$         B) [Ar] $4d^8$         C) [Ar] $3d^8$         D) [Ar] $4s^2 3d^6$         E) [Ar] $3d^{10}$

    Answer: C

33) Name the following: $[Ni(NH_3)_3(H_2O)_3]Cl_2$

    A) nickel(II)trihydrotriamminechloride
    B) nickel(I)triamminetrihydrochloride
    C) triamminetriaquanickel(II)chloride
    D) dichloronickel(II)triamminetrihydride
    E) nickel(III)chloride

    Answer: C

34) Which is the correct chemical formula for potassium hexacyanoferrate (II)?

    A) $K_2 [Fe(CN)_6 ]$
    B) $K [Fe(CN)_6 ]$
    C) $K_6 Fe(CN)_6 ]$
    D) $K_4 [Fe(CN)_6 ]$
    E) $K [FeCN ]_6$

    Answer: D

35) Which of the following compounds can exhibit cis-trans isomerism?

    A) $[Fe(CO)_5 NO_2]^{2+}$

    B) $[Ni(CO)_2(NH_3)_2]^{2+}$

    C) $[MnClBr_3]^{2-}$

    D) $[Cr(H_2O)_6]^{3+}$

    E) $[Cu(CO)_5Cl]^+$

    Answer: B

36) Which of the following species exhibits optical isomerism?

    A) $[Co (NH_3)_4 Cl_2 ]^+$

    B) $[Cr (NH_3)_6 ]^{3+}$

    C) $[Pt (NH_3)_3 Br ]^+$

    D) $[Pt (CN)_2 Cl_2 ]^{2-}$

    E) $[Co (en)_3 ]^{3+}$

    Answer: E

37) The complex ion, $[Ni(NH_3)_6]^{2+}$, has a maximum absorption near 580 nm. Calculate the crystal field splitting energy (in kJ/mol) for this ion. (Planck's Constant $h = 6.626 \times 10^{-34}$ J · s)

    A) 343 kJ/mol         B) 485 kJ/mol         C) 206 kJ/mol         D) 292 kJ/mol         E) 114 kJ/mol

    Answer: C

38) Which element forms +2 ions that are diamagnetic and colorless in solution?

    A) V         B) Ti         C) Cr         D) Zn         E) Mn

    Answer: D

39) Given the spectrochemical series (increasing $\Delta$), $Cl^-$ < $H_2O$ < $NH_3$ < $CN^-$, which of the following species would absorb light of the shortest wavelength?

A) $[Co(H_2O)_6]^{3+}$

B) $[Co(NH_3)_6]^{3+}$

C) $[Co(NH_3)_5 Cl]^{2+}$

D) $[CoCl_6]^{3-}$

E) $[Co(CN)_6]^{3-}$

Answer: E

40) The complex ion $[Ni(Br)_4]^{2-}$ is found to have two unpaired electrons. Use crystal field theory to deduce what geometry is consistent with this observation. ($Br^-$ is a weak field ligand.)

A) linear               B) square planar               C) octahedral               D) tetrahedral

Answer: D