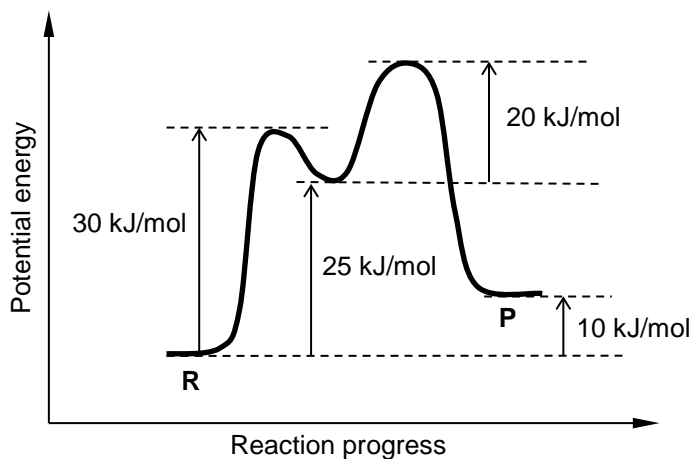


# CHEM 13 NEWS EXAM 2014 - Answers

- 1 Select the correct ending to make the following a true statement. Compared to one litre of water at 25 °C, two litres of water at 25 °C ...
- A is twice as dense
  - B is half as dense
  - \*C has twice the heat capacity
  - D has half the heat capacity
  - E has a vapour pressure that is two times greater
- 2 For which of the following is the number of neutrons equal to the number of electrons?
- \*A  $^{17}\text{O}^-$
  - B  $^{17}\text{O}^+$
  - C  $^{18}\text{O}^-$
  - D  $^{18}\text{O}$
  - E  $^{18}\text{O}^+$
- 3 Which statement is not correct for the reaction below?
- $$2 \text{NO}(\text{g}) \rightleftharpoons \text{N}_2(\text{g}) + \text{O}_2(\text{g})$$
- A At equilibrium, the forward and reverse reactions occur at equal rates.
  - B Reaction to the left or to the right occurs spontaneously until the equilibrium state is reached.
  - C Reducing the volume of the system has no effect on the equilibrium amounts of NO, N<sub>2</sub> and O<sub>2</sub>.
  - D The equilibrium amounts of NO, N<sub>2</sub> and O<sub>2</sub> depend on the initial amounts.
  - \*E The equilibrium value of  $[\text{N}_2][\text{O}_2]/[\text{NO}]^2$  is the same at all temperatures.
- 4 What is the oxidation state of Cr in K<sub>2</sub>CrO<sub>4</sub>?
- A -6
  - B -2
  - C 0
  - D +2
  - \*E +6
- 5 Which of the following processes consumes the greatest quantity of energy *per mole* of sodium?
- A  $\text{Na}(\text{g}) \rightarrow \text{Na}(\text{s})$
  - B  $\text{Na}(\text{l}) \rightarrow \text{Na}(\text{s})$
  - C  $\text{Na}(\text{g}) \rightarrow \text{Na}^+(\text{g}) + \text{e}^-$
  - \*D  $\text{Na}^+(\text{g}) \rightarrow \text{Na}^{2+}(\text{g}) + \text{e}^-$
  - E  $\text{Na}(\text{g}) + \text{e}^- \rightarrow \text{Na}^-(\text{g})$
- 6 Which of the following statements about H<sub>2</sub>SO<sub>3</sub>, a diprotic acid, is true?
- \*A There is just one lone pair on the sulfur atom.
  - B It is a strong acid.
  - C The hydrogen atoms are bonded directly to the sulfur atom.
  - D The OSO bond angles are all approximately 120 degrees.
  - E The oxidation state of sulfur is +6.
- 7 What is the shape of the XeF<sub>4</sub> molecule?
- A tetrahedral
  - B trigonal pyramidal
  - \*C square planar
  - D see-saw
  - E zig-zag

- 8 The density of an ideal gas at 90 °C and 94.0 kPa is 2.80 g/L. What is the molar mass of the gas?
- A 23 g/mol  
B 45 g/mol  
\*C 90 g/mol  
D 180 g/mol  
E 270 g/mol
- 9 Which of the following is an ionic compound?
- A HOCN  
\*B  $\text{NH}_4\text{NO}_2$   
C  $\text{CH}_3\text{NH}_2$   
D  $\text{SiO}_2$   
E  $\text{PH}_3$
- 10 What is the pH of pure water at 37 °C? At 37 °C,  $K_w = 2.4 \times 10^{-14}$ .
- A 6.90  
B 7.10  
C 7.19  
D 7.00  
\*E 6.81
- 11 What is the percentage by mass of Cr in  $\text{Cr}_2\text{O}_3$ ?
- A 34.2%  
\*B 68.4%  
C 76.5%  
D 86.7%  
E 93.2%
- 12 Which of the following is a network covalent solid (an extended network of atoms bonded to each other by covalent bonds)?
- A  $\text{I}_2(\text{s})$   
B  $\text{H}_2\text{O}(\text{s})$   
\*C  $\text{SiC}(\text{s})$   
D  $\text{C}_{10}\text{H}_8(\text{s})$   
E  $\text{CO}_2(\text{s})$
- 13 Which of the following Bronsted-Lowry acid-base pairs is incorrect?
- | Base                 | Acid                    |
|----------------------|-------------------------|
| *A $\text{OH}^-$     | $\text{H}_3\text{O}^+$  |
| B $\text{NH}_2^-$    | $\text{NH}_3$           |
| C $\text{NH}_3$      | $\text{NH}_4^+$         |
| D $\text{CO}_3^{2-}$ | $\text{HCO}_3^-$        |
| E $\text{HSO}_3^-$   | $\text{H}_2\text{SO}_3$ |
- 14 What is the maximum mass of KBr that can be obtained from a mixture containing 13.2 grams of potassium (K) and 22.2 grams of bromine ( $\text{Br}_2$ )?
- A 13.2 g  
B 22.2 g  
\*C 33.1 g  
D 35.4 g  
E 40.2 g
- 15 Diethyl ether,  $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$ , is a liquid at 25 °C and 101 kPa. Which of the following contribute to the attraction amongst molecules in  $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3(\text{l})$ ?
- A dipole-dipole forces only  
B London dispersion forces only  
C hydrogen bonding forces only  
\*D dipole-dipole and London dispersion forces  
E hydrogen bonding and London dispersion forces

- 16 According to the reaction profile below, what is the activation energy for the reverse reaction  $P \rightarrow R$ ?



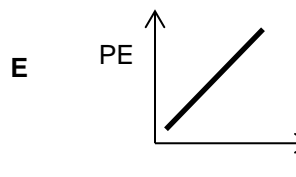
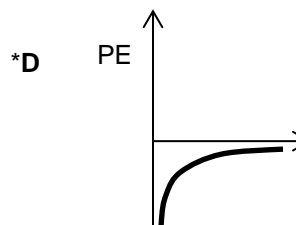
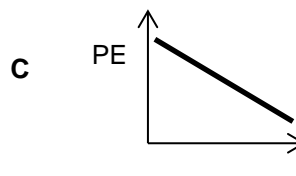
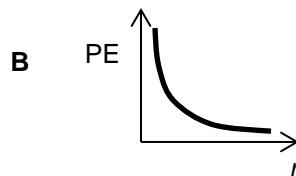
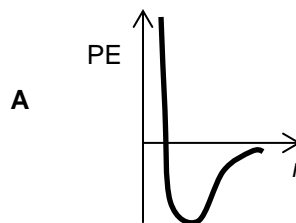
- \*A 35 kJ/mol  
 B 45 kJ/mol  
 C 50 kJ/mol  
 D -10 kJ/mol  
 E -45 kJ/mol
- 17 What is the ground electronic state of  $Mn^{2+}$  ?

- A  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$   
 B  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$   
 \*C  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$   
 D  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^3$   
 E  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^3$

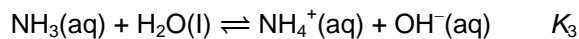
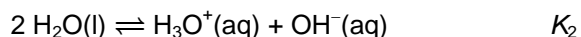
- 18 A solution of  $0.060 \text{ mol L}^{-1}$  pyridine (a weak base) has  $[\text{OH}^-] = 9.1 \times 10^{-6} \text{ mol L}^{-1}$ . What is  $K_b$  for pyridine?

- A  $1.5 \times 10^{-4}$   
 B  $3.0 \times 10^{-4}$   
 C  $8.3 \times 10^{-11}$   
 D  $9.1 \times 10^{-6}$   
 \*E  $1.4 \times 10^{-9}$

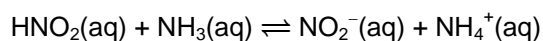
- 19 Which of the following illustrates how the potential energy (PE) of a proton and an electron depends on the distance,  $r$ , between them?



- 20 The equilibrium constants for the following reactions are denoted by  $K_1$ ,  $K_2$ , and  $K_3$ , respectively.



What is the equilibrium constant for the reaction below?



- A  $K_1 - K_2 + K_3$   
B  $K_1 K_3$   
\*C  $K_1 K_3 / K_2$   
D  $K_1 K_2 K_3$   
E  $K_2 / (K_1 K_3)$
- 21 Which of these molecules contains at least one triple bond?
- A oxalic acid,  $\text{H}_2\text{C}_2\text{O}_4$  (HOCCOOH)  
\*B cyanogen,  $\text{C}_2\text{N}_2$  (NCCN)  
C allene,  $\text{C}_3\text{H}_4$  ( $\text{H}_2\text{CCCH}_2$ )  
D ethanal,  $\text{C}_2\text{H}_4\text{O}$  ( $\text{CH}_3\text{CHO}$ )  
E diazene,  $\text{N}_2\text{H}_2$  (HNNH)
- 22 Select the correct ending to make the following a true statement. A catalyst ...
- A always provides a surface on which molecules react  
B lowers the energy of the products  
C induces an alternate reaction pathway with a higher activation energy  
D increases the frequency of collisions between molecules  
\*E is not consumed by the overall reaction although it may be temporarily changed

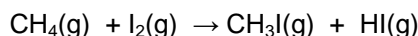
- 23 A current of 4.27 amperes passes through an electrolysis cell containing  $\text{CuSO}_4$  for exactly two hours. How many grams of copper are deposited? Assume the cell operates with 95.1% efficiency. (Note: 1 ampere = 1 coulomb per second)

- A 4.82 g  
\*B 9.63 g  
C 10.1 g  
D 10.6 g  
E 19.2 g

- 24 A mixture of  $\text{N}_2(\text{g})$  and  $\text{Ne}(\text{g})$  has a mass of 2.88 g and occupies a volume of 2.50 L at 298 K and 105 kPa. How many moles of  $\text{N}_2$  are there in this mixture?

- \*A 0.0946 mol  
B 0.106 mol  
C 0.0113 mol  
D 0.112 mol  
E 1.15 mol

- 25 What is  $\Delta H$  for the reaction below?



- A -35 kJ  
\*B +35 kJ  
C -50 kJ  
D +50 kJ  
E -529 kJ

Bond energies (in kJ/mol)
H-C, 413
C-I, 230
H-I, 299
I-I, 151

- 26 How many electrons are needed to fill the 4f subshell of an atom?

- A two  
B six  
C ten  
\*D fourteen  
E eighteen

- 27 Which of the following bonds is the most polar?
- \*A H-O  
B C-N  
C H-C  
D O-N  
E O-F
- 28 Element 119 has yet to be discovered or synthesized. However, because of its position in the periodic table, only one of the following statements about this element is likely to be incorrect. Which statement is incorrect?
- A The element would be a metal.  
\*B The element (call it X) would combine with fluorine to form a compound with formula  $\text{XF}_2$ .  
C The element would be in the s block.  
D The element would react with water to form a basic solution.  
E The element would combine with hydrogen to form an ionic compound.
- 29 Which of the following have three unpaired electrons in their ground electronic states?
- A the third period atoms (Na to Ar)  
B the group 3 atoms (B to Tl)  
\*C the group 15 atoms (N to Bi)  
D  $\text{N}^{3-}$  and  $\text{P}^{3-}$   
E  $\text{B}^{3+}$  and  $\text{Al}^{3+}$
- 30 Which of the following statements concerning the nitrate ion,  $\text{NO}_3^-$ , is incorrect?
- A The ONO bond angles are all  $120^\circ$ .  
\*B One of the nitrogen-oxygen bonds is shorter than the other two nitrogen-oxygen bonds.  
C The nitrogen atom has a formal charge of +1.  
D It is the conjugate base of a strong acid.  
E It is nonpolar.
- 31 Excess  $\text{AgCl}(\text{s})$  is added to a dilute aqueous solution of  $\text{CaCl}_2(\text{aq})$ . Some but not all of the added  $\text{AgCl}$  dissolves. Which of the following conditions must be satisfied at equilibrium?
- A  $[\text{Ag}^+] = [\text{Ca}^{2+}] = \frac{1}{3} [\text{Cl}^-]$   
B  $[\text{Ag}^+] + [\text{Ca}^{2+}] = 3 [\text{Cl}^-]$   
C  $[\text{Ag}^+] + [\text{Ca}^{2+}] = [\text{Cl}^-]$   
\*D  $[\text{Ag}^+] + 2 [\text{Ca}^{2+}] = [\text{Cl}^-]$   
E  $[\text{Ca}^{2+}] = \frac{1}{2} [\text{Cl}^-]$
- 32 The following standard reduction potentials are given.
- $$\text{Fe}^{3+} + \text{e}^- \rightleftharpoons \text{Fe}^{2+} \quad E^\circ = 0.77 \text{ V}$$
- $$\text{IO}_3^- + 6 \text{H}^+ + 5\text{e}^- \rightleftharpoons \frac{1}{2} \text{I}_2 + 3 \text{H}_2\text{O} \quad E^\circ = 1.19 \text{ V}$$
- What is  $E^\circ$  for the reaction below?
- $$\text{IO}_3^- + 6 \text{H}^+ + 5 \text{Fe}^{2+} \rightarrow 5 \text{Fe}^{3+} + \frac{1}{2} \text{I}_2 + 3 \text{H}_2\text{O}$$
- \*A +0.42 V  
B -0.53 V  
C -2.66 V  
D +5.04 V  
E +1.96 V
- 33 Propanoic acid,  $\text{CH}_3\text{CH}_2\text{COOH}$ , is a weak acid with  $\text{p}K_a = 4.87$  at 298 K. What is the pH at the equivalence point in the titration of 30.0 mL of  $0.200 \text{ mol L}^{-1}$  propanoic acid with  $0.200 \text{ mol L}^{-1}$   $\text{NaOH}(\text{aq})$ ? (Note:  $\text{p}K_a = -\log_{10} K_a$ )
- A 4.87  
B 5.07  
C 7.00  
\*D 8.94  
E 9.13

34 Consider the reaction below.



Which of the following conditions maximize the amount of  $\text{Cl}_2\text{(g)}$  present at equilibrium?

- A low temperature, high pressure
- \*B high temperature, low pressure
- C low temperature, low pressure
- D high temperature, high pressure
- E high temperature, pressure has no effect

35 The solubility of  $\text{MnS}$  in water is  $2.3 \times 10^{-6}$  grams per litre. What is  $K_{\text{sp}}$  for  $\text{MnS}$ ?

- A  $4.9 \times 10^{-31}$
- B  $2.8 \times 10^{-23}$
- C  $5.3 \times 10^{-12}$
- \*D  $7.0 \times 10^{-16}$
- E  $2.3 \times 10^{-6}$

36 Which of the following is the weakest acid in water?

- \*A  $\text{H}_2\text{S}$
- B  $\text{H}_2\text{Se}$
- C  $\text{H}_2\text{Te}$
- D  $\text{HBr}$
- E  $\text{HI}$

37 What is the lightest element that has two 4s electrons and eight 3d electrons in its lowest energy state?

- A Fe
- B Ar
- C Kr
- \*D Ni
- E Cu

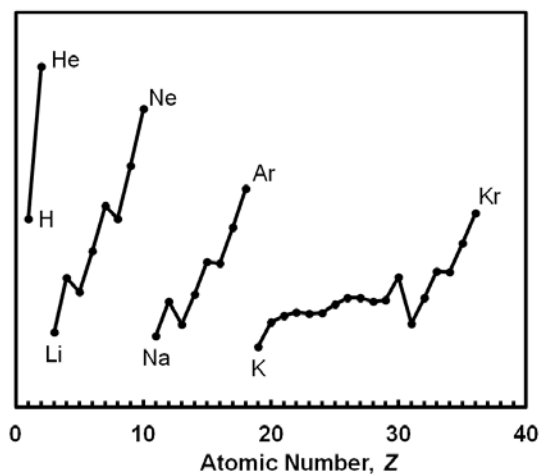
38 Electronegativity is a measure of

- A the magnitude of the charge of an electron
- B the energy released when an electron is added to an atom
- C the energy required to remove an electron from an atom
- \*D the ability of an atom to draw electron density towards itself
- E the average repulsive force experienced by a given electron

39 In which of the following solutions does the solute have the highest degree of ionization? The  $K_{\text{a}}$  values for  $\text{CH}_3\text{COOH}$  and  $\text{HCN}$  are  $1.8 \times 10^{-5}$  and  $4.8 \times 10^{-10}$ , respectively.

- A  $0.10 \text{ mol L}^{-1} \text{ HCN}$
- B  $0.010 \text{ mol L}^{-1} \text{ HCN}$
- C  $0.10 \text{ mol L}^{-1} \text{ CH}_3\text{COOH}$
- D  $0.010 \text{ mol L}^{-1} \text{ CH}_3\text{COOH}$
- \*E  $0.0010 \text{ mol L}^{-1} \text{ CH}_3\text{COOH}$

40 Which property is represented in the graph below?



- A atomic radius
- B electron affinity
- C density
- \*D first ionization energy
- E atomic volume