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**CHEMICAL ENGINEERING REFRESHER PROGRAM**  
**GENERAL INORGANIC AND ORGANIC CHEMISTRY**

1. Balance the following chemical equation:  
 $\_C_8H_{18}(l) + \_O_2(g) \rightarrow \_CO_2(g) + \_H_2O(g)$ 

a. 2, 20, 14, 18	c. 1, 10, 7, 9
b. 2, 25, 16, 18	d. 1, 12, 8, 9
2. Calculate the oxidation number of cobalt in the given compound.  $K[Co(C_2O_4)_2(NH_3)_2]$ 

a. +2	c. +4
b. +3	d. +5
3. Recipient of the 1911 Nobel Prize in chemistry and discoverer of the chemical elements polonium and radium.

a. Marie Curie	c. Niels Bohr
b. Wilhelm Röntgen	d. Antoine Lavoisier
4. In the electromagnetic spectrum, which has a wavelength typically ranging from 15 microns to 1 mm?

a. Far infrared	c. Ultraviolet
b. X-ray	d. Microwaves
5. The radioisotope most widely used in medicine.

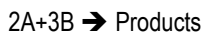
a. $^{131}I$	c. $^{59}Fe$
b. $^{32}P$	d. $^{99m}Tc$
6. A retarding potential of 2.38 volts just suffices to stop photoelectrons emitted from potassium by light of frequency  $1.13 \times 10^{15} s^{-1}$ . What is the work function, W, of potassium?

a. 1.34 eV	c. 6.23 eV
b. 2.29 eV	d. 8.56 eV
7. What is the de Broglie wavelength of an electron travelling at  $7 \times 10^6 m s^{-1}$ ?

a. $1 \times 10^{-10} m$	c. $1 \times 10^{-12} m$
b. $1 \times 10^{-11} m$	d. $1 \times 10^{-13} m$
8. Electrons are accelerated through a p.d. of 54 V. Calculate the de Broglie wavelength of the electron.

a. $1.67 \times 10^{-12} m$	c. $1.67 \times 10^{-10} m$
b. $2.45 \times 10^{-12} m$	d. $2.45 \times 10^{-10} m$

9. Plutonium-239 can be produced by bombarding uranium-238 with alpha particles. How many neutrons will be produced as a by product of each reaction?
- 1
  - 2
  - 3
  - 4
10. When bombarded with neutron, cobalt-59 is converted to \_\_\_\_.
- $^{59}_{27}\text{Co}$
  - $^{58}_{27}\text{Co}$
  - $^{60}_{27}\text{Co}$
  - $^{59}_{26}\text{Co}$
11. Neutron bombardment of plutonium-239 yields americium-240 and another particle. Identify the other particle produced.
- Alpha
  - Beta
  - Gamma
  - X-ray
12. The rate constant for the second order reaction  $2\text{NO}_2 \rightarrow \text{N}_2\text{O}_4$  is 2.79 L/mol-min at 48 deg C. If the initial concentration of  $\text{NO}_2$  is 1.05 M, what is the half-life per 1 mol of  $\text{NO}_2$ ?
- 0.081 min
  - 0.171 min
  - 0.289 min
  - 0.344 min
13. The gas phase reaction below obeys the rate-law expression rate =  $k[\text{PCl}_5]$ . At 400 K, the specific rate constant is  $0.0371 \text{ min}^{-1}$ . How many hours are required to reduce a sample of  $\text{PCl}_5$  to 10% of its original amount?  
 $\text{PCl}_5 \rightarrow \text{PCl}_3 + \text{Cl}_2$
- 1.03 hrs
  - 2.43 hrs
  - 3.98 hrs
  - 5.67 hrs
14. Suppose the activation energy of a certain reaction is 250 kJ/mol. If the reate constant at  $T_1 = 300\text{K}$  is  $k_1$  and the rate constant at  $T_2 = 320 \text{ K}$  is  $k_2$ , then  $k_2/k_1 =$  \_\_\_\_.
- 143
  - 259
  - 332
  - 525
15. In order to study the kinetics of the enzyme succinic thiokinase, the biochemistry lab ordered 250 microcuries ( $\mu\text{Ci}$ ) of a radioactively-labeled compound,  $[1,4\text{-}^{14}\text{C}]$  maleic anhydride. How many disintegrations per second would take place in this sample of maleic anhydride?
- $3.23 \times 10^6$
  - $5.66 \times 10^6$
  - $7.90 \times 10^6$
  - $9.25 \times 10^6$
16. The isotopic mass of  $^{59}_{27}\text{Co}$  is 58.9332 amu. What is its mass deficiency in amu per atom?
- 0.5408
  - 0.6721
  - 0.8711
  - 1.129
17. In the gas phase, methyl isocyanate ( $\text{CH}_3\text{NC}$ ) isomerizes to acetonitrile ( $\text{CH}_3\text{CN}$ );  
 $\text{H}_3\text{C-N}\equiv\text{C}(\text{g}) \rightarrow \text{H}_3\text{C-C}\equiv\text{N}(\text{g})$   
 with  $\Delta H = -89.5 \text{ kJ/mol}$  and  $\Delta G = -73.8 \text{ kJ/mol}$  at 25 deg C.  
 Find the equilibrium constant for this reaction at 100 deg C.
- $6.0 \times 10^9$
  - $8.0 \times 10^9$
  - $6.0 \times 10^{12}$
  - $8.0 \times 10^{12}$
18. Consider the following rate data for the reaction below at a particular temperature.



Experiment	Initial [A]	Initial [B]	Initial Rate of Loss of A
1	0.10 M	0.30 M	$7.20 \times 10^{-5} \text{ M/s}$
2	0.10 M	0.60 M	$1.44 \times 10^{-4} \text{ M/s}$
3	0.20 M	0.90 M	$8.64 \times 10^{-4} \text{ M/s}$

- 1, 2
- 2, 1
- 1, 3
- 3, 1

19. Given:  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$

At 250 deg C, a sample of  $\text{PCl}_5$  was placed in a 24-liter evacuated reaction vessel and allowed to come to equilibrium.

Analysis showed that at equilibrium, 0.42 mole of  $\text{PCl}_5$ , 0.64 mole of  $\text{PCl}_3$ , and 0.64 mole of  $\text{Cl}_2$  were present in the vessel.

Calculate  $K_p$  for the reaction at 250 deg C.

- a. 0.54  
b. 0.91  
c. 1.74  
d. 2.45
20. The half-life for the reactant A in the first order reaction  
 $\text{A} \rightarrow \text{B}$  is 36.2 seconds. What is the rate constant for this reaction at the same temperature?
- a.  $0.091 \text{ s}^{-1}$   
b.  $0.14 \text{ s}^{-1}$   
c.  $0.23 \text{ s}^{-1}$   
d.  $0.98 \text{ s}^{-1}$
21. The following molecules are related in what manner?
- $\text{H}_3\text{C}(\text{C}=\text{O})\text{C}=\text{H}_2$   
|  
 $\text{CH}_3$

$\text{H}_2\text{C}=\text{CH}-\text{CH}_2-(\text{C}=\text{O})-\text{CH}_3$
- a. They are isotopes  
b. They are the same structure  
c. They are constitutional isomers  
d. They are composed of different elements
22. Which of the following is the conjugate base of the following acid:  $\text{SH}_3^+$ ?
- a.  $\text{SH}_2$   
b.  $\text{SH}_3$   
c.  $\text{SH}_2^-$   
d.  $\text{OH}^-$
23. What is the relationship of the two compounds: (3R,4S)-3-chloro-4-methylhexane and (3R,4R)-3-chloro-4-methylhexane?
- a. Enantiomers  
b. Diastereomers  
c. Constitutional isomers  
d. Identical
24. What is the IUPAC name of the expected major product formed upon reaction of HCl with 3-methyl-1-butene?
- a. 1-chloro-2-methylbutane  
b. 1-chloro-3-methylbutane  
c. 2-chloro-2-methylbutane  
d. 2-chloro-3-methylbutane
25. Wilkinson's catalyst accomplishes which of the listed molecular transformation?
- a. syn addition of  $\text{H}_2$  to an alkene  
b. syn dihydroxylation an alkene  
c. anti addition of  $\text{H}_2$  to an alkene  
d. anti dihydroxylation an alkene
26. Which of the following statements is true about propyne,  $\text{H}-\text{C}\equiv\text{C}-\text{CH}_3$ ?
- a. It contains 3 sigma bonds  
b. It contains three pi bonds  
c. The  $\text{H}-\text{C}\equiv\text{C}$  bond angle is about  $109.5^\circ$   
d. The  $\text{C}\equiv\text{C}-\text{C}$  bond is  $180^\circ$
27. Calculate the degree of unsaturation for  $\text{C}_5\text{H}_5\text{Br}_2\text{NO}$ .
- a. 2  
b. 3  
c. 4  
d. 6
28. Determine the percent enantiomeric excess of the mixture containing 12.8 mol (R)-2-bromobutane and 3.2 mol (S)-2-bromobutane.
- a. 20%  
b. 40%  
c. 60%  
d. 80%
29. A mixture contains 3g of (+)-2-bromobutane and 2g of (-)-2-bromobutane. What is the rotation of the mixture, given that (+)-2-bromobutane has a specific rotation of  $+23.1^\circ$ .
- a.  $4.62^\circ$   
b.  $5.77^\circ$   
c.  $6.98^\circ$   
d.  $8.62^\circ$

30. The antimalarial alkaloid quinine,  $C_{20}H_{24}N_2O_2$ , is optically active. An ethanol solution of 8g quinine in 100mL displays a rotation of  $-13.6^\circ$  in a 1dm polarimeter tube. What is the specific rotation of quinine?
- $-85^\circ$
  - $-170^\circ$
  - $-43^\circ$
  - $-26^\circ$
31. Which of the following is a meta-directing deactivator?
- $-\text{COOH}$
  - $-\text{OH}$
  - $-\text{NH}_2$
  - $-\text{Cl}$
32. Reaction involving the reduction of aldehyde or ketone to the corresponding alkane via a dithioacetal with the presence of  $\text{H}_2$  and Raney nickel.
- Wolff-Kishner reduction
  - Clemmensen reduction
  - Mozingo reduction
  - Markovnikov reaction
33. What is the IUPAC name of tosyl chloride, commonly abbreviated as  $\text{TsCl}$ .
- 1-Methylbenzene-1-sulfonyl chloride
  - 2-Methylbenzene-1-sulfonyl chloride
  - 3-Methylbenzene-1-sulfonyl chloride
  - 4-Methylbenzene-1-sulfonyl chloride
34. Name the following compound:
- $$\begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\ | \quad | \\ \text{H}_3\text{C}-\text{C}=\text{C}-\text{CH}-\text{CH}_3 \\ | \\ \text{CH}_2\text{CH}_3 \end{array}$$
- 2-ethyl-1,1,3-trimethylbutene
  - 2,4-dimethylhexene
  - 3-ethyl-2,4-dimethyl-2-pentene
  - 4-ethyl-1,3-dimethyl-3-pentene
35. Which of the following is the rate law for the following  $\text{S}_\text{N}2$  reaction?
- $$\text{1-bromopropane} \xrightarrow{\text{NaCN}} \text{Butanenitrile}$$
- $\text{Rate} = k[\text{1-bromopropane}]$
  - $\text{Rate} = k[\text{NaCN}][\text{1-bromopropane}]$
  - $\text{Rate} = k[\text{NaCN}]$
  - $\text{Rate} = k[\text{NaCN}]^2$
36. Which of the following describes the effect of a catalyst on a reaction?
- It lowers the free energy of the products.
  - It makes the reactants less stable.
  - It changes the equilibrium constant.
  - It lowers the energy of activation.
37. Treatment of alkyl halide with a base that is sterically hindered yields a \_\_\_\_.
- Zaitsev product
  - Hofmann product
  - Grignard product
  - Wittig product
38. Oxymercuration-demercuration of propene produces \_\_\_\_.
- 2-propanol
  - propanoic acid
  - propanal
  - 2-propanone
39. What is the IUPAC name for the following compound?
- $$\text{PhCH}_2\text{CH}_2\text{CHO}$$
- 4-benzylbutanal
  - 3-phenylpropanal
  - 3-benzylpropanal
  - 4-phenylbutanal
40. The electrophile in the sulfonation reaction of benzene is:
- $\text{SO}_2^+$
  - $\text{SO}_3^+$
  - $\text{H}_2\text{SO}_3$
  - $\text{SO}_3$