CHEMISTRY 202
Hour Exam III
December 5, 2019
Dr. D. DeCoste

Name ______**KEY**________

Signature ____________________________

T.A. ________________________________

This exam contains 23 questions on 12 numbered pages. Check now to make sure you have a complete exam. You have two hours to complete the exam. Determine the best answer to the first 20 questions and enter these on the special answer sheet. Also, circle your responses in this exam booklet. **Show all of your work and provide complete answers to questions 21, 22, and 23.**

1-20	(60 pts.)	_________
21	(10 pts.)	_________
22	(20 pts.)	_________
23	(30 pts.)	_________
Total	(120 pts)	_________

Useful Information:

Table 15.6

Summary of the Kinetics for Reactions of the Type $aA \longrightarrow$ Products That Are Zero, First, or Second Order in [A]

	Order		
	Zero	First	Second
Rate law	Rate = k	Rate = $k[A]$	Rate = $k[A]^2$
Integrated rate law	$[A] = -kt + [A]_0$	$\ln[A] = -kt + \ln[A]_0$	$\frac{1}{[A]} = kt + \frac{1}{[A]_0}$
Plot needed to give a straight line	[A] versus t	ln[A] versus t	$\frac{1}{[A]}$ versus t
Relationship of rate constant to the slope of the straight line	Slope = $-k$	Slope = $-k$	Slope = k
Half-life	$t_{1/2} = \frac{[A]_0}{2k}$	$t_{1/2} = \frac{0.693}{k}$	$t_{1/2} = \frac{1}{k[A]_0}$

PV = nRT

R = 8.314 J/Kmol = 0.08206 Latm/molK

$k = Ae^{-Ea/RT}$

$$\ln\left(\frac{k_2}{k_1}\right) = \frac{E_a}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

1. How many of the following statements are **true**?

- The electron affinity values for the first 20 elements can be endothermic or exothermic, but are mostly exothermic.
- The ionization energy values for the first 20 elements can be endothermic or exothermic, but are mostly exothermic.
- The ionization energy values for the first 20 elements can be endothermic or exothermic, but are mostly endothermic.
- If we know the ionization energy value for element X, we can determine the electron affinity value for the ion X^-.

a) 0 | b) 1 | c) 2 | d) 3 | e) 4

2. All of the following have similar values of $\frac{2^{nd} \text{ ionization energy}}{1^{st} \text{ ionization energy}}$ except for which one?

a) Li | b) Be | c) C | d) N | e) Ne

3. At standard conditions, iodine is a diatomic solid [$I_2(s)$], which has $\Delta H°_{sublimation} = 62.0$ kJ/mol. Given this, and that you have access to bond energies (Table 13.6), which is the best estimate of the standard enthalpy of formation ($\Delta H_f°$) for HI(g)?

a) –35.5 kJ/mol | b) –4.5 kJ/mol | c) 26.5 kJ/mol | d) 35.5 kJ/mol | e) 57.5 kJ/mol

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4, 5. Consider the following molecules/ions: XeO_4, PO_4^{3-}, ClO_3^-, and SO_3. In all cases, the first atom listed in the formula is central. Compare Lewis structures when the octet rule is obeyed and when formal charge is minimized.

4. For which species is the **difference in formal charge** on the central atom the **largest** between the Lewis structure obeying the octet rule and the one minimizing formal charge?

a) XeO_4 | b) PO_4^{3-} | c) ClO_3^- | d) SO_3 | e) The difference is equally large for at least two of them.

5. For which species is the **difference in formal charge** on the central atom the **smallest** between the Lewis structure obeying the octet rule and the one minimizing formal charge?

a) XeO_4 | b) PO_4^{3-} | c) ClO_3^- | d) SO_3 | e) The difference is equally small for at least two of them.

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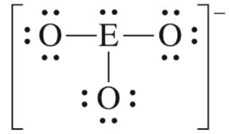
6. Considering the bond energies in Table 13.6 as a reference, which of the following is the best estimate of the bond energy between the nitrogen atoms in nitrous oxide (N_2O, with the structure NNO)? Be sure to take formal charge into account.

a) 160 kJ/mol | b) 418 kJ/mol | c) 575 kJ/mol | d) 875 kJ/mol | e) 941 kJ/mol

7. Consider the following Lewis structure, where E is an unknown element:



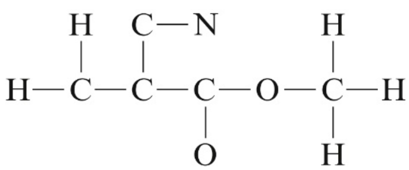
On the periodic table you were given for this exam, how many elements could be element E?

a) 1 b) 2 c) 4 d) 5 e) 8

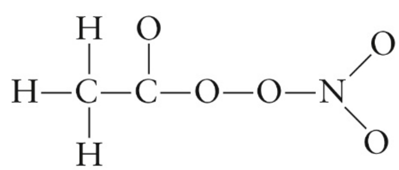
8. In studying VSEPR we have discussed eleven different names for shapes of small molecules (bent, linear, octahedral, see-saw, square planar, square pyramidal, tetrahedral, trigonal planar, trigonal bipyramidal, trigonal pyramidal, and T-shape). Consider molecules consisting of at least two different types of atoms. If all you know is the name of the shape of such a molecule, for how many of the names can you conclude that the molecule **must** be polar?

a) 1 b) 3 c) 5 d) 8 e) 11

9. Consider the two skeletal structures below:



Structure I



Structure II

Complete the Lewis structures for both. In which case is it **not possible** to have formal charges for all atoms to equal zero?

a) It is not possible in Structure I but it is possible in Structure II.
b) It is not possible in Structure II but it is possible in Structure I.
c) Neither of the structures can have formal charges for all atoms equal to zero.
d) Both structures can have formal charge for all atoms equal to zero.

10. We know that at 1 atm, the boiling point of substance A is greater than the boiling point of substance B. From this we can correctly conclude how many of the following?

- The molecules of substance A and the molecules of substance B exhibit different types of intermolecular forces.
- The vapor pressure of substance A is greater than the vapor pressure of substance B at the same temperature.
- Molecules of substance A are not symmetrical.
- Substance A is a more ideal gas than substance B.

a) 0 b) 1 c) 2 d) 3 e) 4

11. Consider the following substances:

- Ethane (C_2H_6)
- Ethanol (CH_3CH_2OH)
- Formaldehyde (H_2CO)
- Methane (CH_4)
- Methanol (CH_3OH)

The boiling points of these substances (not necessarily in the order of the list above) are: –161°C, –89°C, –21°C, 65°C, and 78°C. Which substance has a boiling point of 65°C?

a) ethane b) ethanol c) formaldehyde d) methane **[e) methanol]**

12. Consider the reaction $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ which reacts rather quickly (similarly to the iodine clock reaction in lecture). Because of this, we can modify the method of initial rates approach to include time. You run three trials of this reaction at constant temperature and obtain the following data, where

$$\text{rate} = -\frac{d[Cl_2]}{dt}$$

Trial	**$[NO]_0$**	**$[Cl_2]_0$**	**Time for reaction**
1	0.100*M*	0.100*M*	12.56 sec
2	0.100*M*	0.200*M*	3.141 sec
3	0.200*M*	0.200*M*	1.571 sec

If we run a fourth trial for which $[NO]_0 = 0.300M$, what is the value of $[Cl_2]_0$ that will give us a time of reaction of 2.718 seconds?

a) 0.0154*M* b) 0.0268*M* c) 0.0854*M* **[d) 0.124*M*]** e) 0.519*M*

13. Consider the reaction represented by the equation $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$. You run this reaction at constant temperature and obtain the following data:

time (minutes)	**$[N_2O_5]$ (*M*)**
0	1.24×10^{-2}
10	8.92×10^{-3}
20	6.97×10^{-3}
30	5.72×10^{-3}
40	4.85×10^{-3}
50	4.21×10^{-3}

Determine $[NO_2]$ at the time of the second half-life.

a) 3.10×10^{-3} *M*
b) 9.30×10^{-3} *M*
[c) 1.86×10^{-2} *M*]
d) 3.28×10^{-2} *M*
e) 3.72×10^{-2} *M*

14. Consider a reaction as represented by the general equation aA + bB → Products.

You run this reaction at the same (constant) temperature in two experiments and obtain the following data:

Expt #1 {$[B]_0 = 5.0\ M$ }

Time (sec)	[A]
0	0.010 *M*
40.	0.0050 *M*
120.	0.0025 *M*

Expt #2 {$[B]_0 = 10.\ M$ }

Time (sec)	[A]
0	0.010 *M*
20.	0.0050 *M*
60.	0.0025 *M*

Determine the rate constant, k, for the reaction at this temperature (units with *M* and sec).

a) 6.25×10^{-5} b) 0.012 c) 0.50 d) 2.5 e) 5.0

15. You invent a very interesting new substance that, while not being used up during a reaction, keeps the rate constant the same for a given reaction but changes the order from second-order to zero-order. You set up two experiments for a reaction of the form aA → products, starting both experiments with $[A]_0 = 10.0M$. In one case you run the reaction that follows a second order rate law. In the other case, you add your new substance that changes it to zero-order. In both cases $k = 0.10$, in units of *M* and seconds.

You start the reactions at the same time. How much time elapses until the concentrations of [A] in both experiments are equal again?

a) The concentrations remain equal throughout the experiment because the rate constants (*k*) are the same.
b) The concentrations never become equal again because the rates are different.
c) 1 second
d) 50 seconds
e) 99 seconds

16. We can define the quarter-life of a reaction as the **total time** it takes for a reactant to reach one quarter (¼) of its original concentration (designated by $t_{1/4}$). Suppose you run three reactions (each of the form aA → products,), a zero-order, a first-order, and a second-order, such that all of their first half-lives are equal. What is the ratio of the quarter-lives?

$t_{1/4}$ (zero-order): $t_{1/4}$ (first-order): $t_{1/4}$ (second-order)

a) 1:1:1
b) 3:4:6
c) 6:4:3
d) 1:2:4
e) 4:2:1

17. You find that a reaction proceeds 31.4 times faster at 31°C than at 25°C. If we assume that the activation energy corresponds to a bond being broken, which of the following could be the rate determining step in the mechanism (use Table 13.6 as a reference)?

a) $H_2 \rightarrow 2H$
b) $H_2O \rightarrow H + OH$
c) $CO \rightarrow C + O$
d) $HF \rightarrow H + F$
e) $N_2 \rightarrow 2N$

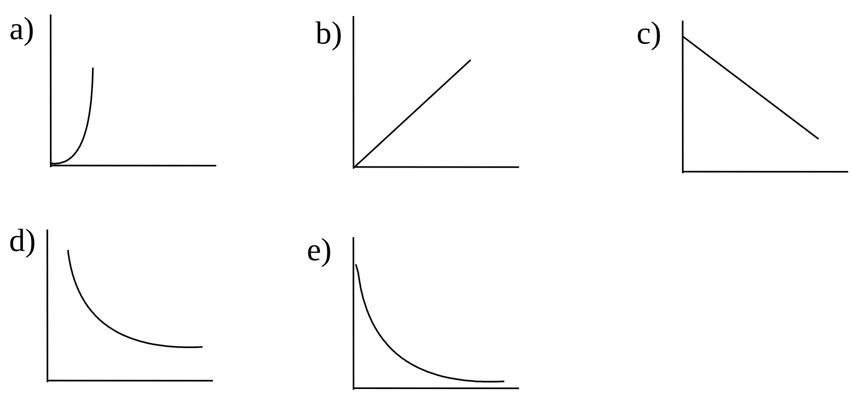
18. Consider the reaction represented by the equation $3O_2(g) \rightarrow 2O_3(g)$. You run this reaction at constant temperature and obtain the following data:

Time (seconds)	**P_{total} (atm)**
0	1.0000
300.0	0.8333
450.0	0.8000
600.0	0.7778
900.0	0.7500

Determine the rate constant, *k*, for this reaction at this temperature (units with atm and sec).

a) 5.556×10^{-4} b) 6.079×10^{-4} c) 6.670×10^{-4} d) 2.310×10^{-3} e) 3.333×10^{-3}

19, 20. Choose the best graph for the plots described below.



19. k vs E_a for a series of chemical reactions with different activation energy values at the same temperature. Assume that the pre-exponential factor, A, is constant for all of the reactions. E

20. $t_{1/2}$ vs [A] at constant temperature for a reaction type aA → products which is second order in A. D