Kinetics Class Notes

Some reactions are fast, like the very first one you saw on the first day. Remember the synthesis of water?

1. Hydrogen gas + oxygen gas + a touch of heat ⟶ __________ + _______________

Some are rather slow, remember the decomposition of hydrogen peroxide?

2. Hydrogen peroxide ⟶ ______________ + _________________

That second one was SOOOOOOO SLOOOOWWWWWW it took a catalyst to make it happen!

3. The catalyst was potassium iodide, a white salt. Where do we write it in that equation?

____ (put it there now)

4. Kinetics is the part of chemistry that studies the _______________ of ________________________

5. We will again examine reactions that absorb energy to occur, called ___________________________

6. And their opposites, reactions that emit energy as a product, called ___________________________

One of the simplest reactions we know is the combustion of methane.

$$CH_{4(G)} + 2O_{2(G)} \rightarrow 2H_2O_{(G)} + CO_{2(G)} + \text{energy}$$

We know a lot about this reaction too, let's start naming things:

7. This reaction is combustion, it's _________________, the heat of reaction for this reaction is

_______________ (from table I).

8. The energy is written with the ____________________________.

9. The forward reaction is _______________________________ because energy is a <u>product</u>.

10. The mole ratio of this equation would be: ______________________________________

11. The thermochemical mole ratio would be ____

12. This reaction tends to be irreversible because???? _______________________

____

____.

This reaction is different: $2H_2O_{(L)}$ + energy → $O_{2(G)}$ + $2H_{2(G)}$

14. For starters, since energy is a reactant, this reaction must be ______________________ with a ______ΔH.

15. In fact, on table I, the actual ΔH is _____________________________(?)

16. Wait a second, is this reaction even on table I? ____

____

17. What is the ΔH then? ___________________

This reaction is

18. ___________________, and the energy is written with the _____________________________ (it's absorbed)

19. It is also _______________________ because it has but one reactant.

Look at 7 reactions. You decide if they are exothermic or endothermic, PLUS you indicate a +ΔH, or a – Δ something special about 25 and 26, see if you can figure that out.

	Reactions from table I	Actual ΔH	Exo or endo
20	$2C_8H_{18(L)} + 25O_{2(G)} \rightarrow 16CO_{2(G)} + 18H_2O_{(G)}$		
21	$N_{2(G)} + O_{2(G)} \rightarrow 2NO_{(G)}$		
22	$2C_{(S)} + H_{2(G)} \rightarrow C_2H_{2(G)}$		
23	$4Al_{(S)} + 3O_{2(G)} \rightarrow 2Al_2O_{3(S)}$		
24	$C_3H_{8(G)} + 5O_{2(G)} \rightarrow 3CO_{2(G)} + 4H_2O_{(G)}$		
25 *	$CO_{2(G)} \rightarrow C_{(S)} + O_{2(G)}$		
26 *	$NaOH_{(S)} \xrightarrow{H_2O} Na^{+1}{}_{(AQ)} + OH^{-1}{}_{(AQ)}$		

Something special about #25 and #26. See if you can figure that out!

25* $CO_{2(G)} \rightarrow C_{(S)} + O_{2(G)}$

26* $NaOH_{(S)} \xrightarrow{H_2O} Na^{+1}_{(AQ)} + OH^{-1}_{(AQ)}$

#25 is backwards on table I from the way it's written here. On Table I the reaction that has carbon + oxygen forming into CO_2 and it has a ΔH o f –393.5 kJoules/mole.
Since this reaction is written in reverse, we reverse the ΔH also: the ΔH of this reaction is +393.5 kJ/mole.

#26 is NOT really a reaction, rather it is a phase change for the NaOH from Solid → Aqueous

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Let's talk about driving from our school to Johnson City High School. It's 7.07 miles according to mapquest.com If you drive there in 20 minutes, you are driving 7.07 miles in 0.33 hours.

That works to be about 21.1 miles per hour. The time it takes to drive there is related to, but…

27. ____

28. ____

29. The rate has a weird unit of ____________________ or it can be understood to be:

The 4 factors that affect the rate of a chemical reaction (NOT the time it takes)

30. ________________________________ – hotter usually means the reaction will happen faster

31. ________________________________ – which allows the reactants to react faster

32. ______________________________ – more stuff, more chance for a reaction to happen

33. Adding a ________________________

The first three of these will work because of ONE reason, the catalyst works a different way. All of these four ways will increase the rate of a chemical reaction

The first three factors are all related to making the particles that are in the reaction move faster. Why would more particle motion make for a faster reaction?

34. ____

What actually happens at the invisible atomic level during a chemical reaction?

35. _______________________ _______________________

With _________________________________and also ____________________ _____________________.

36. When particles don't collide, they ____________ ___________________.

Let's review those 4 factors right here, <u>do they increase the likelihood of collisions</u>??

37. Increase in Temperature – YES OR NO

38. Increase reactant surface area – YES OR NO

39. Increase the concentration of the reactants – YES OR NO

40. Adding a catalyst – YES OR NO That's 3 yes votes in a row, but #4 is a big no here!

What's a POTENTIAL ENERGY DIAGRAM?

41. Potential energy diagrams ____

____

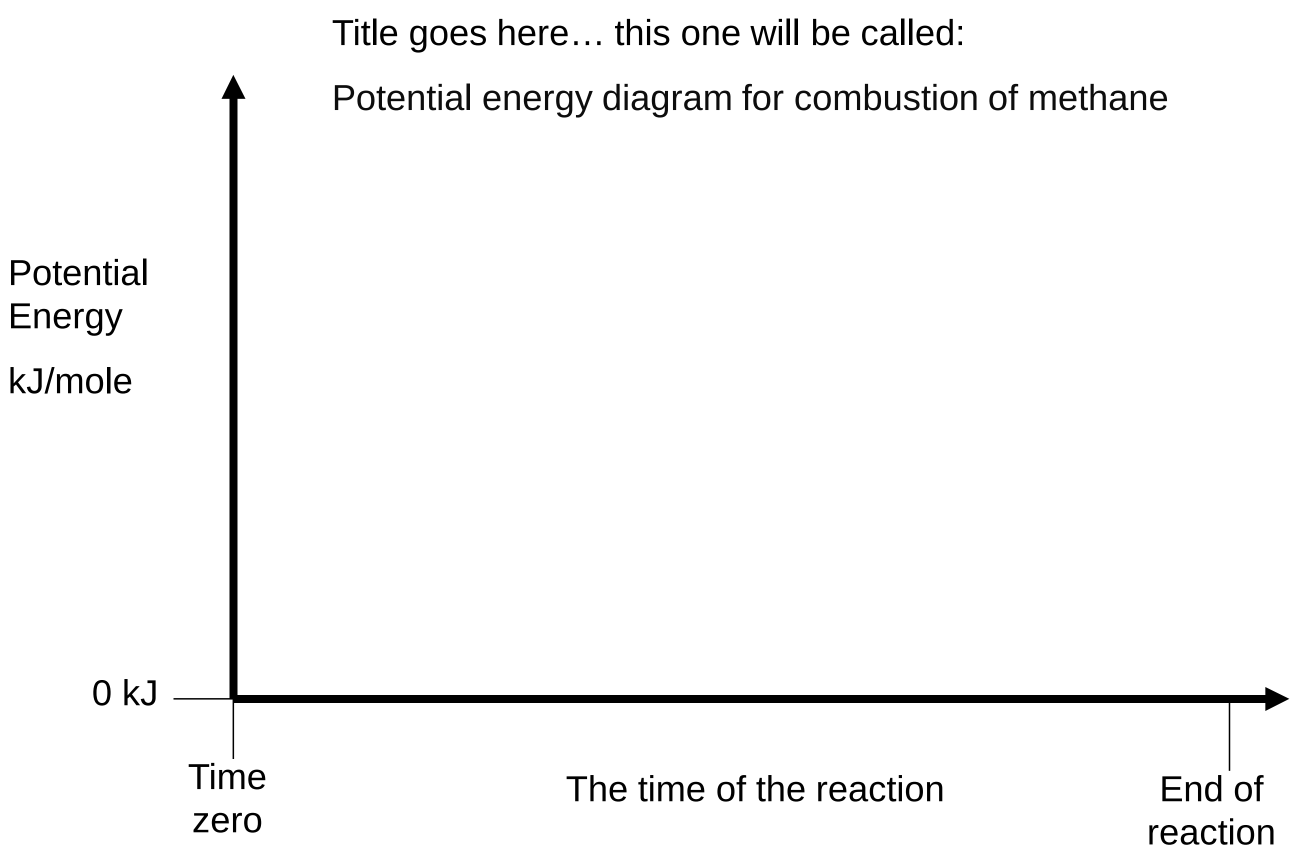
42. They come in two flavors, one for the ________________________ reactions with a _____ΔH and another

kind for the ______________________reactions with a _____ΔH.

We will draw on the next pages an exothermic potential energy diagram for the combustion of methane. All exothermic potential energy diagrams "look" similar, the only real difference is the Y axis scale. The exothermic reactions (think now) give off energy as a product, so they must START with more energy than the end up with since much energy is released into the Universe. It's "lost" from the reaction, but hardly lost. The Law of Conservation of energy is:

43. ____.

How to draw a potential energy diagram (we'll do lots of these, don't worry now)



Make sure this diagram has these labels with units, and these definitions below:

45. Potential Energy of Reactants: ____

46. Potential Energy of Products: ____

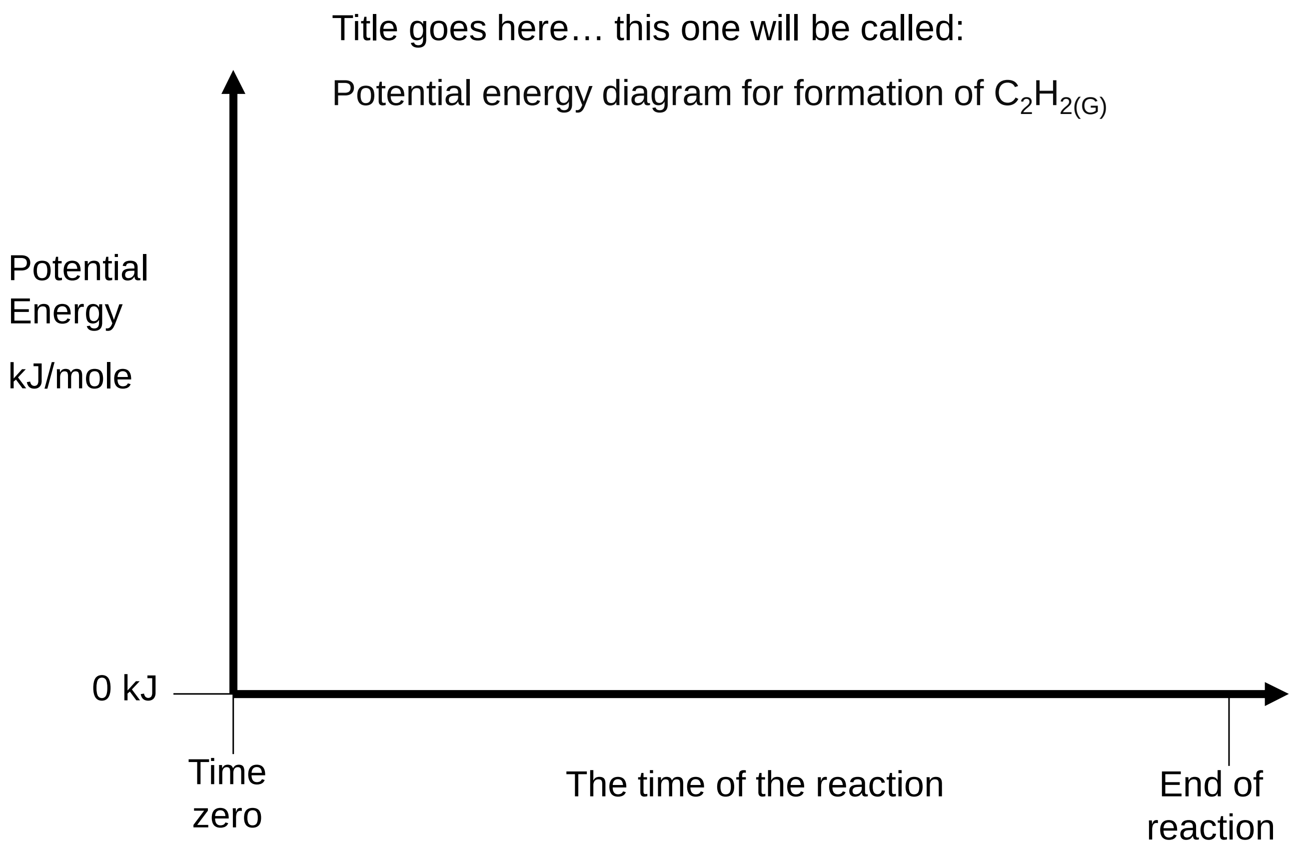
47. ΔH: ____ Here the ΔH is ____________________

48. Activation Energy (AE): ____

Endothermic Potential Energy Diagrams

These are nearly identical to the exothermic diagrams, but since the ΔH is a different sign, the graph "goes the other direction. The Products have MORE POTENTIAL ENERGY than the reactants started with, because these endothermic reactions ABSORB ENERGY from the environment.

How to draw a potential energy diagram (we'll do lots of these, don't worry now)



49. Table I shows us that the heat of reaction (ΔH) for the synthesis of C_2H_2 is __________

50. Draw the curve as shown by your teacher. Label the AE which stands for __________________________

51. Label the PE Reactants and PE Products, which stands for:

52. Indicate the ΔH with an arrow (mark it with a SIGN, as necessary).

53. Now we will draw the PE Diagram for the synthesis of acetylene C_2H_2 using Tale I

Include: PE Reactants, PE Products, ΔH (positive or negative), AE, Activated Complex (AC), and a decent title with axis labels with proper units.

54. Do the same for dissolving of NaOH into water (not a real chemical reaction, but is energetic)

55. Define POTENTIAL ENERGY – ______________________________

56. Define ACTIVATION ENERGY – ______________________________

57. Define ACTIVATION COMPLEX – ______________________________

58. Define ΔH – ______________________________

59. Define POTENTIAL ENERGY DIAGRAM – ______________________________

____

60. Draw the PE Diagram for the synthesis of Aluminum Oxide. Make the balanced thermochemical equation your title.

61. We will attempt to draw the PE diagram for the dissolving of sodium chloride into water. (include all)

62. Draw the PE diagram for the combustion of propane.

63. Where is the “missing energy” if the products have LESS potential energy than the reactants did?

____.

64. Draw the Potential Energy Diagram for LiBr dissolving into water (show all parts to diagram)

65. Draw the Potential Energy Diagram for NH_4Cl dissolving into water (show all parts to diagram)

66. Define Catalyst: ____

____.

____.

67. Using DOTTED lines, show the affect of a catalyst on the above two PE diagrams.

Repeat: How does a catalyst work?

68. ____

69. ____

The reaction we watched was how a catalyst (potassium iodide) speeds up the decomposition reaction of hydrogen peroxide into water and oxygen

70. Does the amount of heat energy given off change between the uncatalyzed or catalyzed reactions? ______

71. Does it "seem so"? ______________

72. How would we explain that the reaction with the catalyst "seems to give off so much more energy"?

____

73. Are most chemical reactions REVERSIBLE? ____________, but some are because…

____

74. What is one of the MOST IMPORTANT reversible reactions? ________________________________

75. Define Dynamic Equilibrium: ____

____.

76. If you have a closed system with this ammonia/nitrogen + hydrogen reaction, and you pump in extra NH_3,

what happens?

77. State LeChatleier's Principle

78. List the 4 types of chemical stresses you can apply to a dynamic equilibrium

Using this dynamic equilibrium, determine which way the equilibrium must shift when these particular stresses are applied.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 + \text{energy}$$

79. Add nitrogen

80. Add hydrogen

81. Add ammonia

82. Add energy (heat)

83. Add pressure

84. Remove nitrogen

85. Remove hydrogen

86. Remove ammonia

87. Remove energy (cool system)

88. Lower pressure

We will ASSUME this is a dynamic equilibrium because of the arrows, but in truth the reverse will be not likely.
Here we are learning about dynamic equilibrium and the impact different chemical stresses have on a reaction.
That this reaction does not normally reverse is to be overlooked now. This is conceptual chemistry, not actual chemistry.

$$4Al + 3O_2 \rightleftharpoons 2Al_2O_3 + \text{Energy}$$

89. Add aluminum oxide

90. Remove oxygen

91. Remove heat (cool system)

92. Add aluminum

93. Add Heat

94. Increase pressure

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95. In dynamic equilibrium, pressure ONLY affects ________________________. It has no affect on either

_________________________________ or ____.

$$CH_{4(G)} + 2O_{2(G)} \rightleftharpoons CO_{2(G)} + 2H_2O_{(G)} + \text{energy}$$

this again is NOT normally reversible, we are just "playing" with concepts here.

96. Add methane

97. Add water

98. Add heat

99. Remove carbon dioxide

100. Remove heat

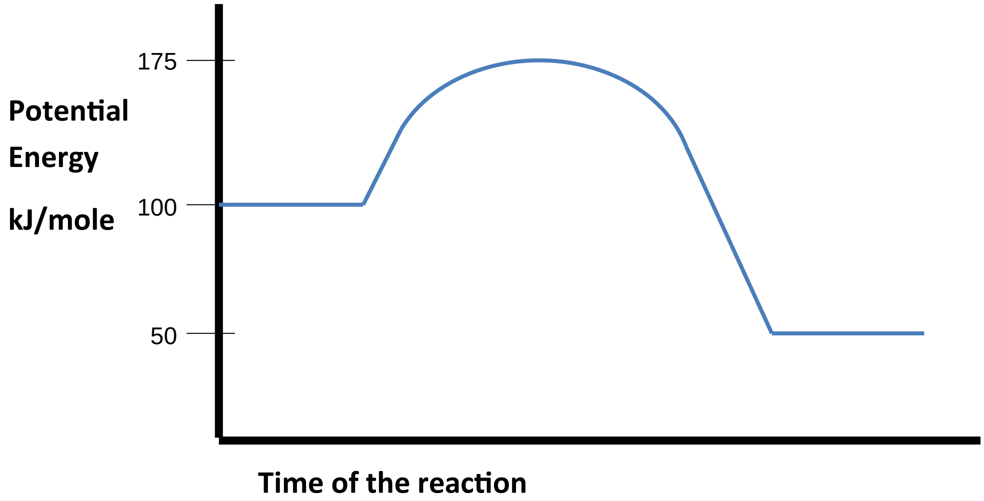
101. Remove methane

102. Add carbon dioxide

103. Increase pressure

104. Decrease pressure

Using this diagram, answer the following questions. Use ACTUAL numbers whenever possible.



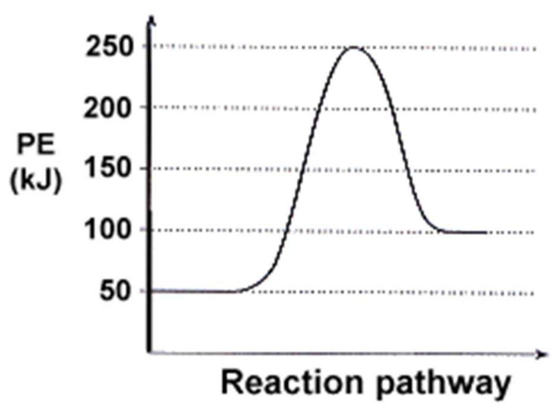
105. Is this an exo or endothermic reaction? ___________________________

106. What is the potential energy of the activated complex? _____________________________

107. What is the PE of the products? ________________________________

108. What is the ΔH? ____________________________________

109. What would be a possible activation energy with a catalyst? _________________________________



110. What is the PE of the reactants? ______________

111. What is the activation energy

for this reaction? ______________________

112. Is this reaction exo or endothermic? _________

114. What are possible AE values for this reaction with a catalyst? _____________________________

115. What is the ΔH for this reaction? ____________________________

116. Would the ΔH for this reaction change with a catalyst? ______________________________

This is NOT a real chemical reaction but you should be able to manage with the symbols.

$$3A_{(G)} + B_{(S)} \rightleftarrows 3C_{(G)} + D_{(G)} + \text{energy}$$

118. Add heat
119. Add B
120. Inc. pressure
121. Remove D
122. Add C

123.State LeChatleier's Principle (again, without looking) this is important to memorize.

124. State the four types of chemical stresses you could apply to a dynamic equilibrium to upset it.

125. What are the 4 things you could do to speed up a chemical reaction? Three go together (why?) and one works differently (how?)

126. Compare or Rank these phases of matter for entropy: Water Steam Ice

127. If all of these particles are at the same temperature (305 K) and the same pressure (105 kPa), rank them for most to least entropy? Carbon monoxide octane Sucrose (table sugar)

128. What does the NYS Chemistry Curriculum have to say that might be worth memorizing as well?