Faster than a Speeding Mullet

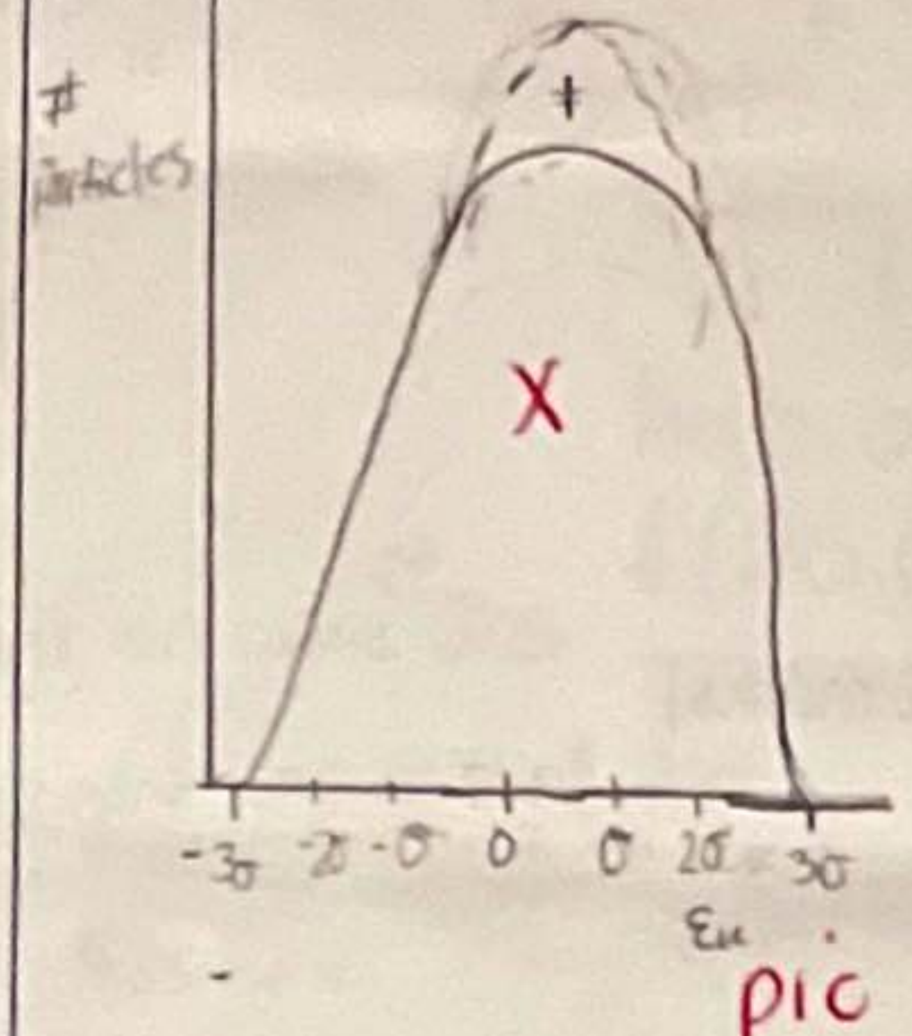
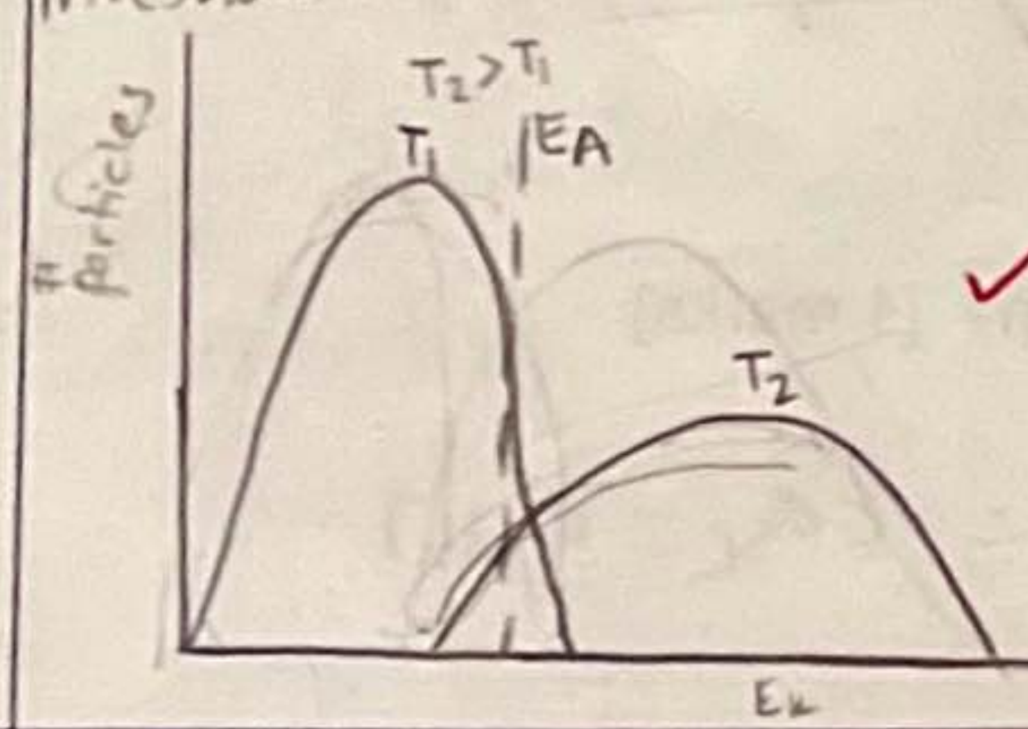
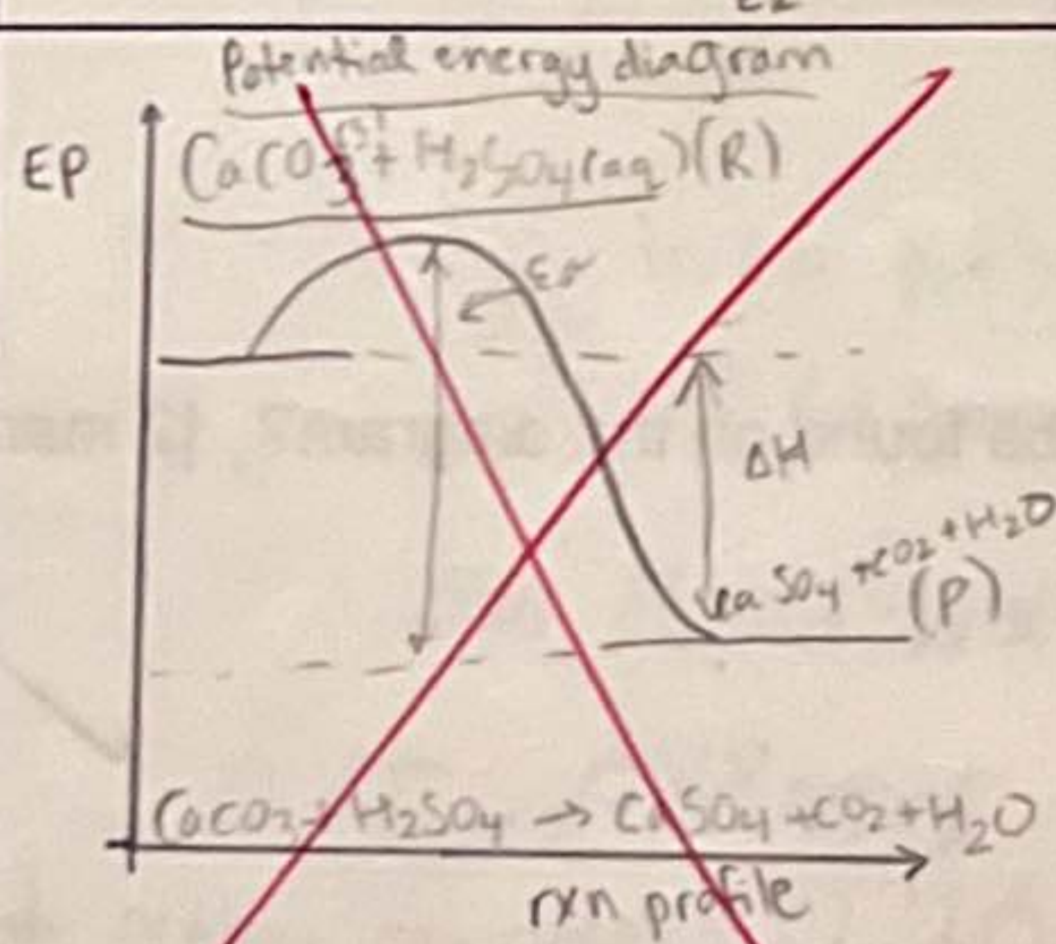
[67 marks]

50/67 752

Communication [9 marks] 5.5

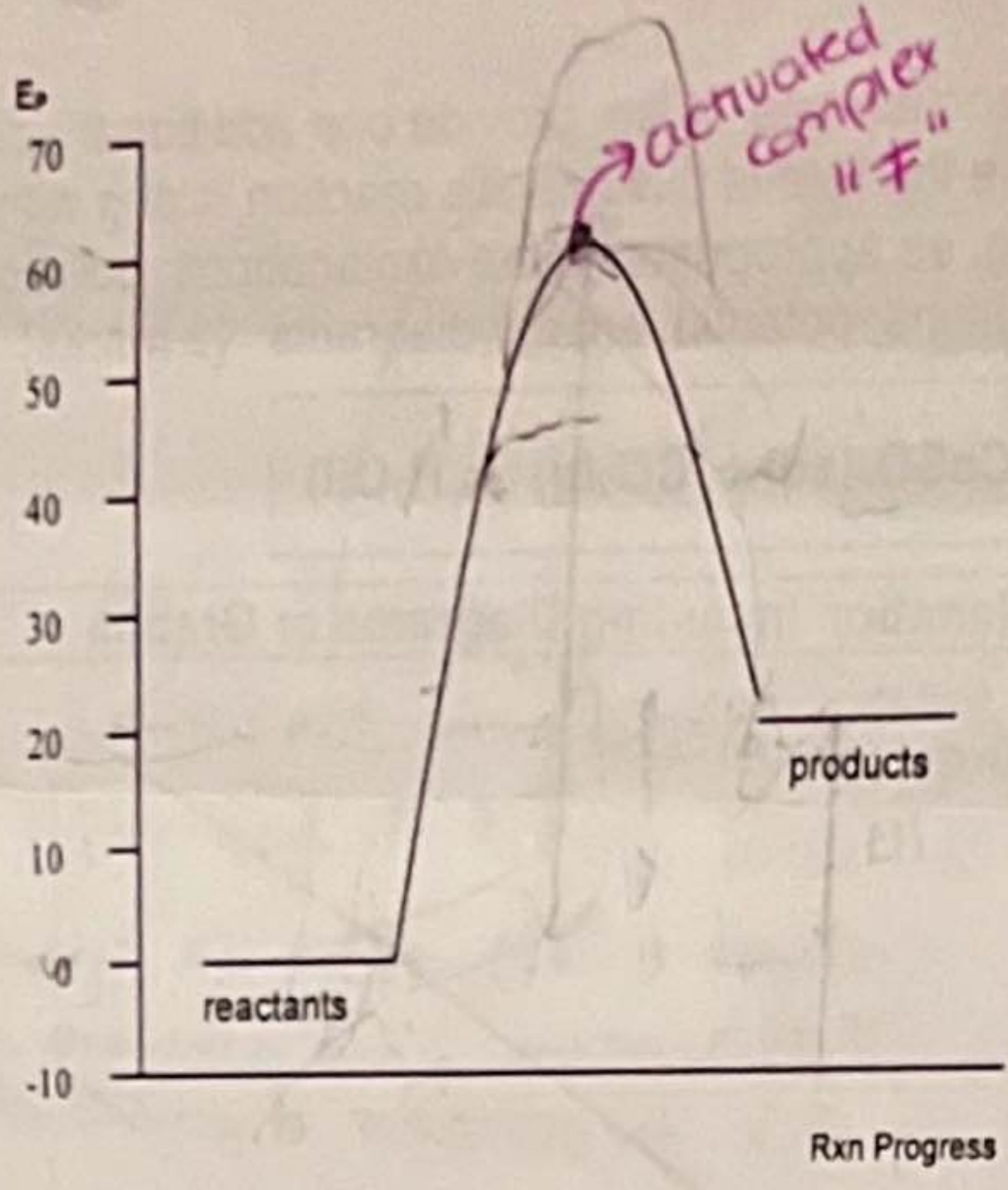
1. Explain, in detail, how each action affects the reaction rate. Also, provide one additional action (other than catalyst addition) that would increase the rate of this specific reaction, along with a detailed explanation. Include all of the following, as appropriate, in the explanations: collision theory explanation, Maxwell-Boltzmann distributions, potential energy diagrams. [9 marks]

$$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + CO_2(g) + H_2O(l)$$

Action	Full Collision Theory Explanation Including Diagrams or Graphs
2 — Addition of an Inhibitor	 pic The Maxwell-Boltzmann distribution states that most of the data will lie between (-σ and σ) 68% more than 68% lies between -2σ and 2σ, and 100% of data is between -3σ to 3σ. (the distribution of particles relative to their EK) *nothing to do w/ question* Adding an inhibtor increases the activation energy, and fewer particles have that E_A needed to cross the threshold - It slows down reaction rate (opposite of catalyst)
2 — Increase in the Temperature	Increase in temp. lowers the E_A so more particles have enough energy to meet the min. energy threshold (activation complex)  Increase in temp. increases reaction rate because there is more kinetic energy and the particles are colliding harder, so with more effectiveness This follows collision Theory, which states that particles must collide effectively in order to react (in the right orientation and with effective collisions) to break bonds + form new ones
1.5 — Increase concentration of (aq) H_2SO_4	 Increase in [ ] increases collisions b/c there are now more particles to collide. If you ↑ [ ] the reactants have more chances to collide

Making Connections [7 marks] (6)

2. Answer the questions given the following reaction profile.



(a) Is this reaction exothermic or endothermic? Explain. [2 marks]

endothermic b/c reactants have less energy than products ✓

(b) What is the activation energy for the forward reaction? [1 mark]

$E_A = 60 kJ$ (forward) ✓

5

(c) What is the activation energy for the reverse reaction? [1 marks]

$E_A = -80 kJ$ (reverse) ✗ $E_{a_r} = 40 kJ$

6

(d) What is the ΔH for the reverse reaction? [1 mark]

ΔH = -20 kJ (reverse)

(e) What is an activated complex and where would it be found on the diagram? [2 marks]

It is the point where new bonds are forming and old bonds are breaking. It is at the top of the 'hill' and would be shown with ‡ ✓

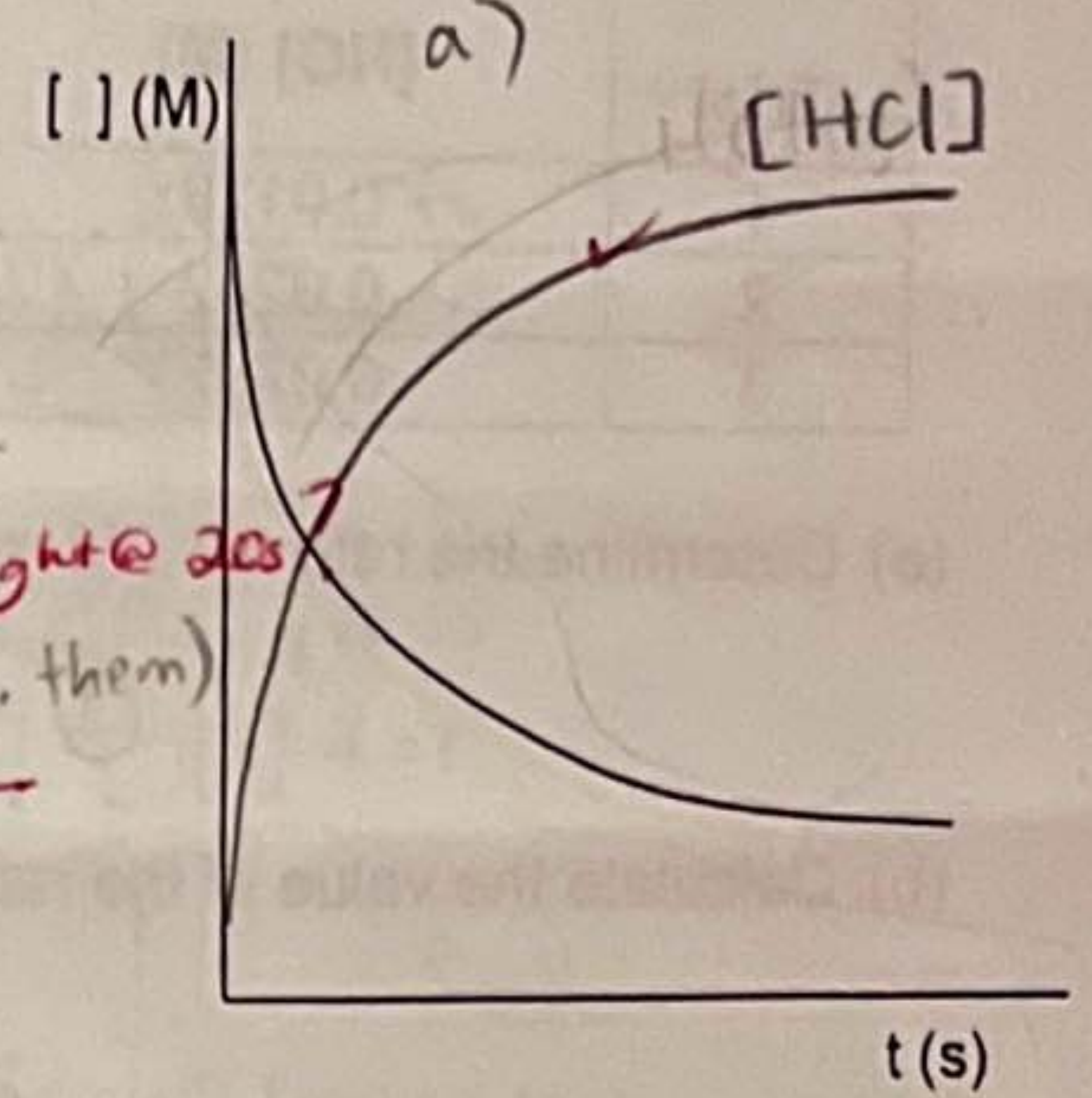
6 + 21 = 27

Knowledge & Understanding [8 + 25 = 33 marks]

3. For the reaction, $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$, a chemist plots $[H_2]$ versus time on the following graph.

(a) On the same graph, draw a line to represent [HCl] versus time. [1 marks]

(b) Explain how to calculate the instantaneous rate of consumption of hydrogen gas at 20 s. [3 marks]



Find the slope of tangent line right near 20s, like at t=19.99 and t=20.01 (avg. them)

why not right @ 20s

math → $\frac{f(a+h)-f(a)}{h}$

3

$h=0.01$, $a=20s$

$\frac{f(20.01)-f(20)}{0.01}$, Same with f(19.99),

average them out, find, in math term, "instantaneous rate of change" or in this case, "consumption

- locate point on curve @ 20s
- draw tangent line @ that point
- find slope of this line
- slope = IROC

4. The decomposition of sulfuryl chloride, $SO_2Cl_2(g) \rightarrow SO_2(g) + Cl_2(g)$, is a first order reaction. At 320°C, the rate constant is $2.2 \times 10^{-5}\ s^{-1}$. Calculate the half-life of the reaction, in hours. [4 marks]

① $r = 2.2 \times 10^{-5}\ s^{-1}$ K=320°C

↳ $0.000022\ s^{-1}$

② $\ln 2 = Kt_{1/2}$

$0.693 = (320)(t_{1/2})$

$t_{1/2} = \frac{0.002166084 5}{60} = \frac{0.000036101}{60}$ mins $= 0.000000601$ hours

↳ 2SD = 6.0×10^{-7} hours

3

$\ln 2 = kt_{1/2}$

$0.693 = (2.2 \times 10^{-5}\ s^{-1})t_{1/2}$

$t_{1/2} = 3.15 \times 10^4\ s$

$3.15 \times 10^4 \left(\frac{1\ min}{60\ s}\right)\left(\frac{1\ hour}{60\ min}\right)$

≈ 8.75 hours

1. For the ... is 48 kJ/mol.

Inquiry [18 marks]

4. The following data was collected for the gas phase reaction between nitrogen (II) oxide and oxygen, $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$, at 273°C.

Trial	[NO] (M)	[O_2] (M)	Initial Rate of Appearance of NO_2 (M/s)
1	0.0126	0.0125	1.41×10^{-2}
2	0.0252	0.0250	1.13×10^{-1}
3	0.0252	0.0125	5.64×10^{-2}

×2 ÷2 ÷4 ×1/2

(a) Determine the rate law. [3 marks]

$r = k[NO]^x[O_2]^y$

$r = k[NO]^1[O_2]^2$ ($r = k[NO]^2[O_2]^1$)

$(\frac{1}{2})^x = \frac{1}{2}$, $x = 1$

$2^x = 4$, $x = 2$

$2^2 = 4$

(b) Calculate the value of the rate constant. [4 marks]

$k = ?$

$r = k[A]^2[B]$

$r = k[NO]^1[O_2]^2$

$1.41 \times 10^{-2} = k[0.0126]^1[0.0125]^2$

0.0564
0.113

$0.0141 = k[0.0126][0.00015625]$

$k = 7161.90 M^{-1}s^{-1} \rightarrow 3SD \rightarrow 7160 M^{-2}s^{-1}$ $7.11 \times 10^3 M^{-2}s^{-1}$

(c) What is the rate of appearance of NO_2 when [NO]=0.015 M and [O_2]=0.025 M? [4 marks]

$r = 7161.90[0.015]^1[0.025]^2$

$r = 7639\ 36000$

$= 76.4 \times 10^7 Ms^{-1}$

∴, the rate of appearance of NO_2 is $76.4 \times 10^7 Ms^{-1}$

$r = 7.11 \times 10^3 M^{-2}s^{-1}(0.015M)^2(0.025M)$

$= 4.0 \times 10^{-2} Ms^{-1}$

not based on units above

13.5

(d) What is the order of the reaction w.r.t NO, w.r.t O_2 and overall? [3 marks]

$NO \rightarrow 1 \rightarrow 2$

$O_2 \rightarrow 2 \rightarrow 1$ OK.

overall → 3

(e) Is this reaction homogeneous or heterogeneous? [1 mark]

homogeneous, all reactants are in the same state

(f) Is it possible that this reaction proceeds by a single elementary step? Explain fully. [3 marks]

No, because if it did, the coefficients in the reaction would match the exponents of the rate law. They don't; the exponent on NO is not 2 and on O_2 is not 1.

OK.

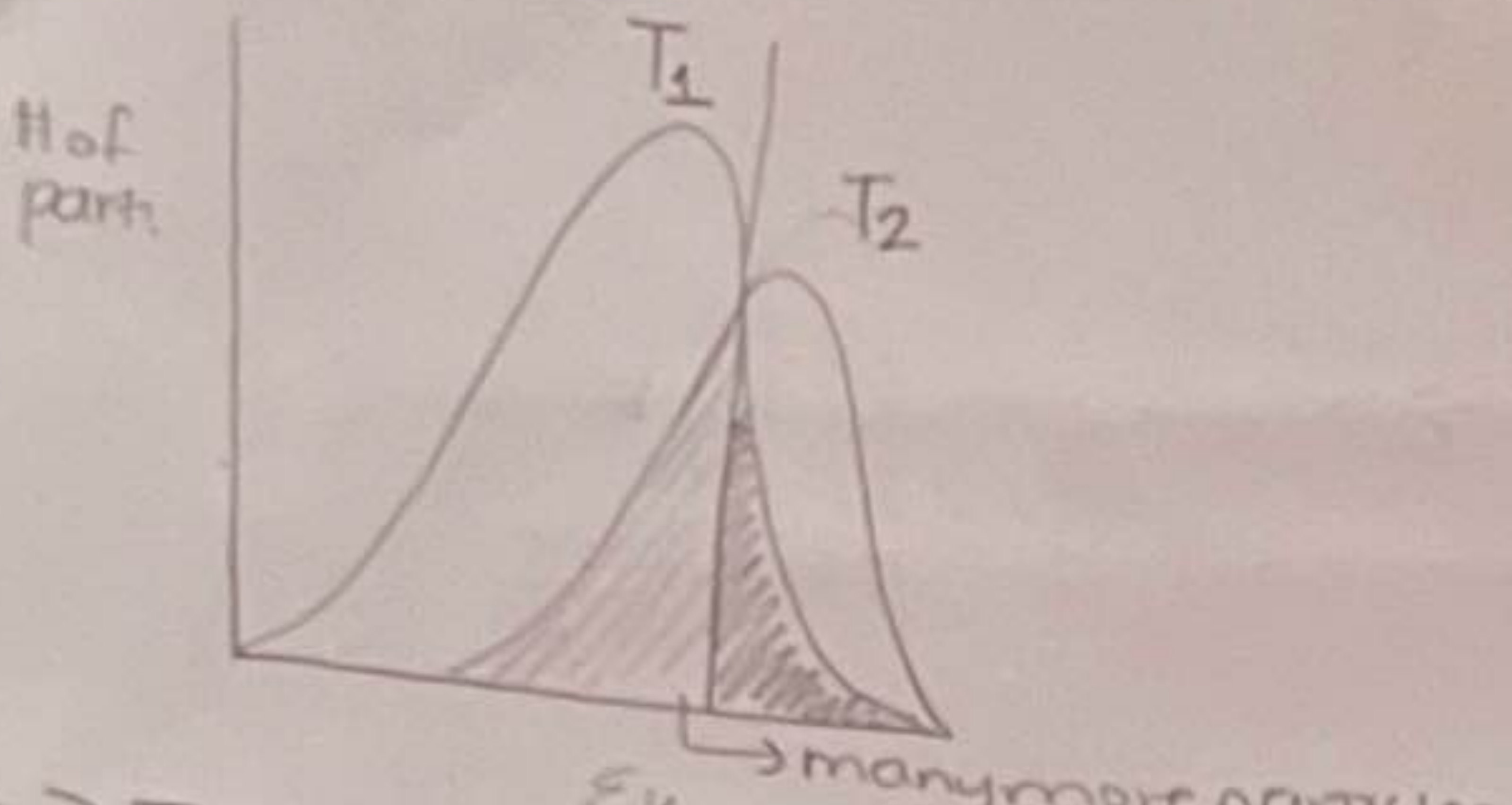
Yes - the rate law depends on the R.D.S.

the RDS has $2NO + O_2 \rightarrow$ products

overall eqn is $2NO + O_2 \rightarrow 2NO_2$

Since the products match for both equations, it is possible the mechanism has 1 elementary step

1. ✓ According to the collision theory it states that anything that ↑ the effectiveness of collisions will increase the rxn rate. ↑ the temp, ↑ Ek within/ between the particles and this will make more collisions and ∴ ↑ the rxn rate.

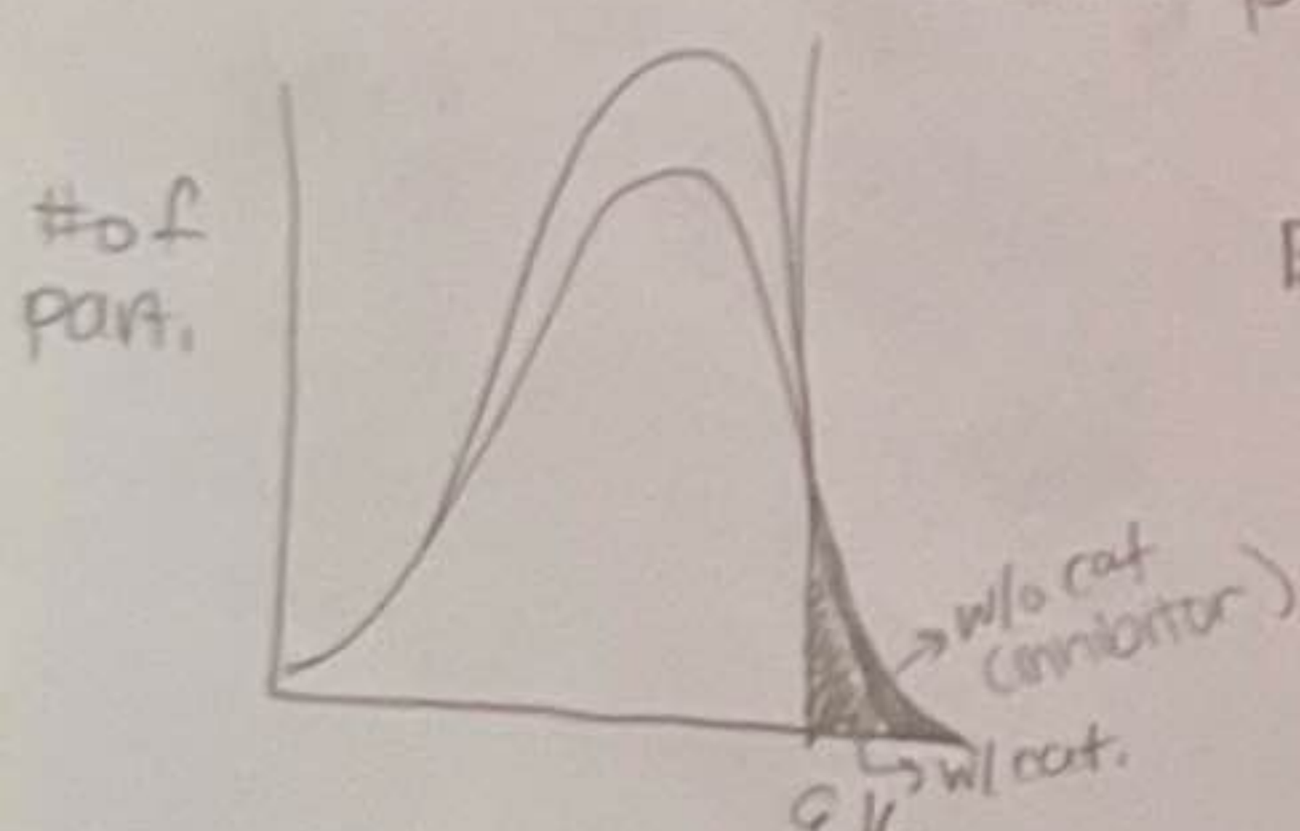


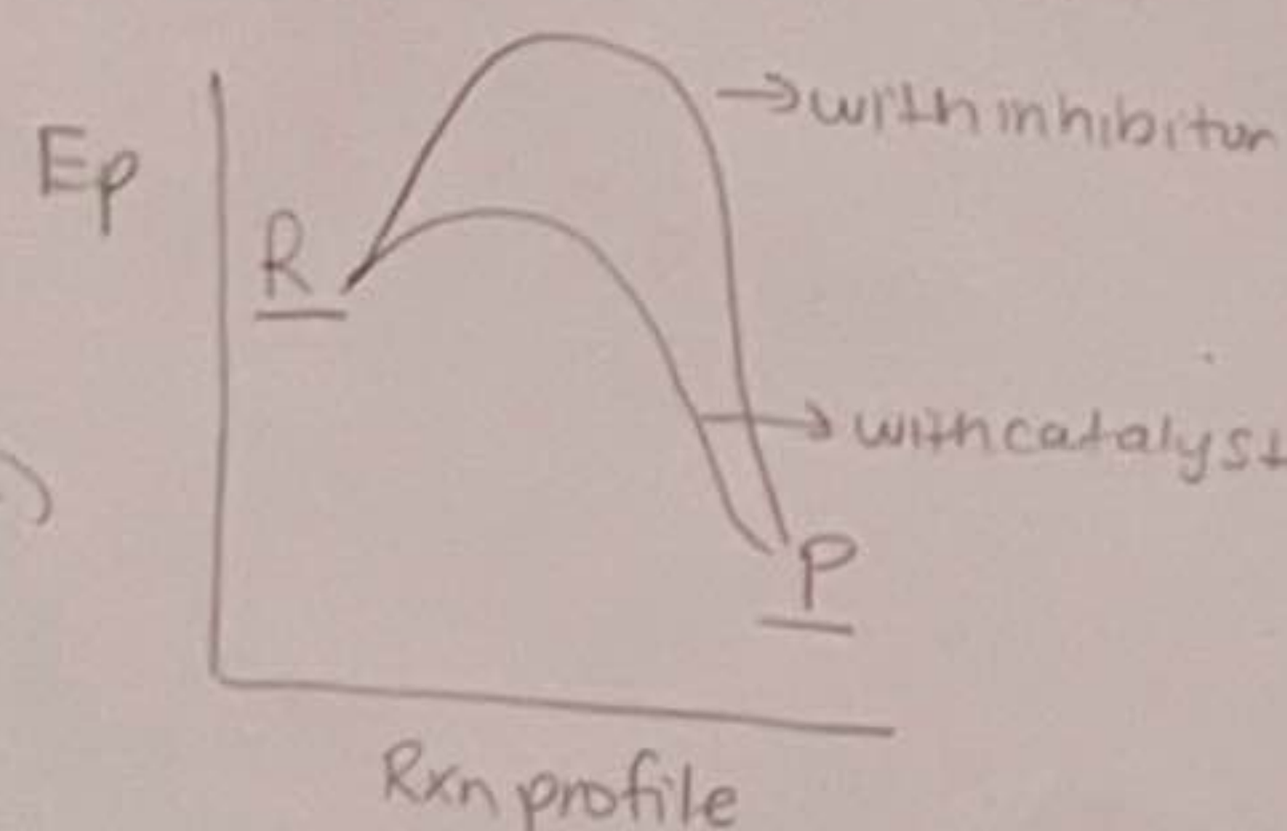
$T_2 > T_1$

✓

2. Can't ↓ [ ] of Bromine but b/c you want to ↓ the amount of Br you could instead of spreading the hetergenous mixture to ↑ S.A you could put it in to a test which would lessen the chances of collisions ∴ ↓ Bromine and ↓ the rxn rate.

3. ✓ An inhibitor is the opposite to a catalyst which it ↑ the Ea of the rxn so less reactants can reach ≠ and become products. If you add an inhibitor this will ↓ the rxn rate allowing less reactants to become products.





4. ✓ a) $r = k[A]^0[B]^2$ ✓
$r = k[B]^2$

5. ① ↑ in S.A of solid nickel(II) oxide

② ↑ in concentration of gas