I. 閱讀以下文章，請於括號內之候選答案裡挑選出一個最正確的答案(每題 3 分)，遇底線處請填入正確答案(每題 5 分)。最後簡答文後所列問題，必要時列出算式，中英文皆可 (70%)。

※ 注意：請於試卷內之「非選擇題作答區」作答，並應註明作答之題號。

抗疫先鋒台大生機系陳教授開發一種可以一對一吸附病毒(V)的奈米顆粒(P)，它跟病毒之間的結合有如下的關係：

$$PV \xleftrightarrow{k} P + V$$

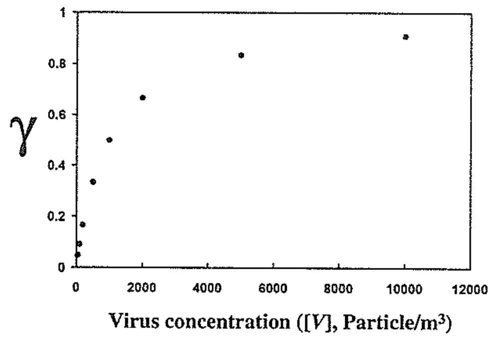
$$k = \frac{[P][V]}{[PV]}$$

此處，k 應為[(1) association; bonding; dissociation] constant，k 的單位為[(2) concentration; mass; temperature; pressure; volume]，k 與兩者間的 affinity 呈[(3) insignificant; negative; positive; significant] correlation。

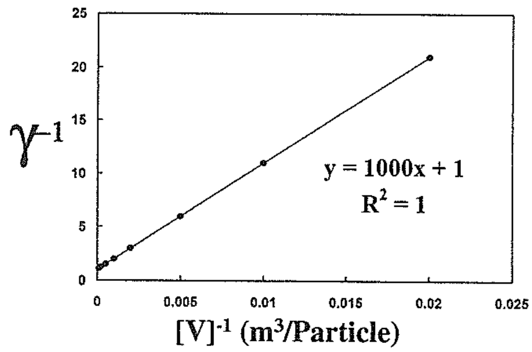
英明的陳教授於是將此神奇奈米顆粒噴在口罩上形成抗菌薄膜，並預測此抗菌薄膜與薄膜附近的病毒濃度合乎 Langmuir adsorption isotherm 的關係：

$$\gamma = \frac{[PV]}{[P]+[PV]} = \frac{1}{\frac{[P]}{[PV]}+1} = \frac{1}{\frac{k}{[V]}+1}$$

此處，γ是口罩上的奈米顆粒與病毒結合的比例。A 同學分析不同口罩上的 γ與口罩旁的病毒濃度(Particle/m^3)，得到如下圖關係。



由圖可知，口罩若長期暴露在一定濃度的病毒下， γ值會[(4) decrease; hold constant; increase]到[(5) deprivation; threshold; saturation]。為了證明陳教授 Langmuir adsorption isotherm 的推測，B 同學則用 γ 倒數與病毒濃度倒數作圖，得到完美的直線。



見背面

依上圖可得知，此奈米顆粒的 k 值為____(6)____，單位為____(7)____。

醫院的抗疫英雄戴著此口罩，發現 γ值會隨時間(t)呈指數上升。

$$\gamma = 1 - e^{-\frac{t}{\tau}}$$

在醫院使用 24 小時之後，γ值變成 0.2，此時口罩附近的病毒濃度為____(8)____(Particle/m^3)。

請定性或定量回答以下問題 (每題 8 分)

(9) B 同學為何比 A 同學更能證明陳大教授的推測？是根據什麼參數？

(10)試闡述 γ值可能的量測方式？

(11)以 γ值推估此抗疫口罩的 time constant 為多少？

(12)根據人體免疫數據顯示，人類免疫系統只能處理 100 Particle/m^3 的病毒量，如此一來，請計算該口罩於醫院的有效使用時間？

(13)承上題，若口罩的 time constant 一定，而要開發能配戴 24 小時的防疫口罩，所使用奈米顆粒的 k 值應該為何？

接次頁

II. 專業英文填空：請參考下列答案庫，限用英文，每題 2 分、文法錯誤扣 1 分 (30%)。
※ 注意：請於試卷內之「非選擇題作答區」作答，並應註明作答之題號。

答案庫(含單數名詞、原型動詞、形容詞與副詞)：activation; active; catalyst; catalyze; competitive; enzyme; first order; higher; intersect; kinetic; logarithmic; lower; gas constant; Michaelis constant; non-competitive; reciprocal; selective; second order; slope; specificity; steady; substrate; thermal; transient; uncompetitive.

Biological reactions ___(14)___ by enzymes are generally very ___(15)___ to certain chemicals known as the ___(16)___ of the enzymes; the chemicals bind to the ___(17)___ site of the enzyme to become an ES complex with a much lower ___(18)___ energy.

$$E + S \xleftrightarrow{K_1/K_{-1}} ES \xrightarrow{K_2} E + P$$

The reaction therefore can occur under mild conditions (e.g. temperature and pressure) with sufficient efficiency. Based on Michaelis-Menten model, the reaction rate is related to the concentration of ES complex as the following ___(19)___ kinetics.

$$V = -\frac{d[S]}{dt} = \frac{d[P]}{dt} = K_2[ES]$$

In the ___(20)___ state, the concentration of ES complex can be solved as follows.

$$\frac{d[ES]}{dt} = 0$$

$$K_1[E][S] = (K_{-1} + K_2)[ES]$$

$$\frac{[ES]}{[E]} = \frac{K_1[S]}{K_{-1} + K_2} = \frac{[S]}{K_M}$$

$$\frac{[ES]}{[E]+[ES]} = \frac{[ES]}{[E]_t} = \frac{[S]}{K_M + [S]}$$

$$[ES] = \frac{[S]}{K_M + [S]}[E]_t$$

An enzymatic reaction rate therefore increases non-linearly with the substrate concentration and reaches a maximum as the substrate concentration being much higher than ___(21)___ .

$$V = K_2[ES] = K_2[E]_t \frac{[S]}{K_M + [S]} = V_{\max} \frac{[S]}{K_M + [S]}$$

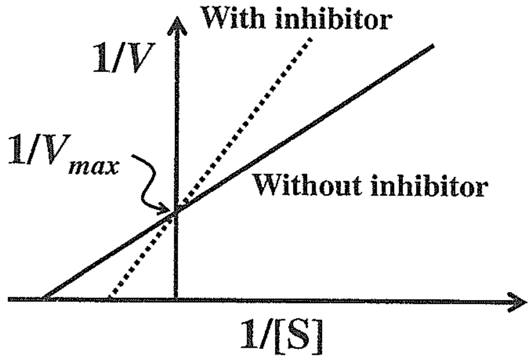
Since the kinetics is not linear, it will be more convenient to analyze the parameters by plotting the ___(22)___ values of the reaction rate against those of the substrate concentration.

見背面

The ____(23)____ of the plot will be proportional to the Michaelis constant.

$$\frac{1}{V}=\frac{1}{V_{\max}}(\frac{K_M+[S]}{[S]})=\frac{1}{V_{\max}}+(\frac{K_M}{V_{\max}})\frac{1}{[S]}$$

The following plots show the existence of ____(24)____ inhibitors which will alter the apparent K_M (the slope of the plot) of the enzyme kinetics without changing the V_{max}. The higher the inhibitor concentration, the ____(25)____ the apparent K_M.



According to Arrhenius expression, the rate constant (k_2) of an enzyme will be affected by the temperature (T) and the activation energy (Ea). The reaction for the substrate possesses an Ea ____(26)____ than other chemicals, which is the origin of the substrate ____(27)____ of the enzyme.

$$k_2=Ae^{-Ea/RT}$$
$$V=k_2[ES]=Ae^{-Ea/RT}[ES]$$
$$\ln V=\ln A[ES]-\frac{Ea}{R}(\frac{1}{T})$$

The best way to calculate the activation energy is to multiply the slope of the semi-logarithmic plot of V against ($1/T$) with the negative value of ____(28)____.

試題隨卷繳回