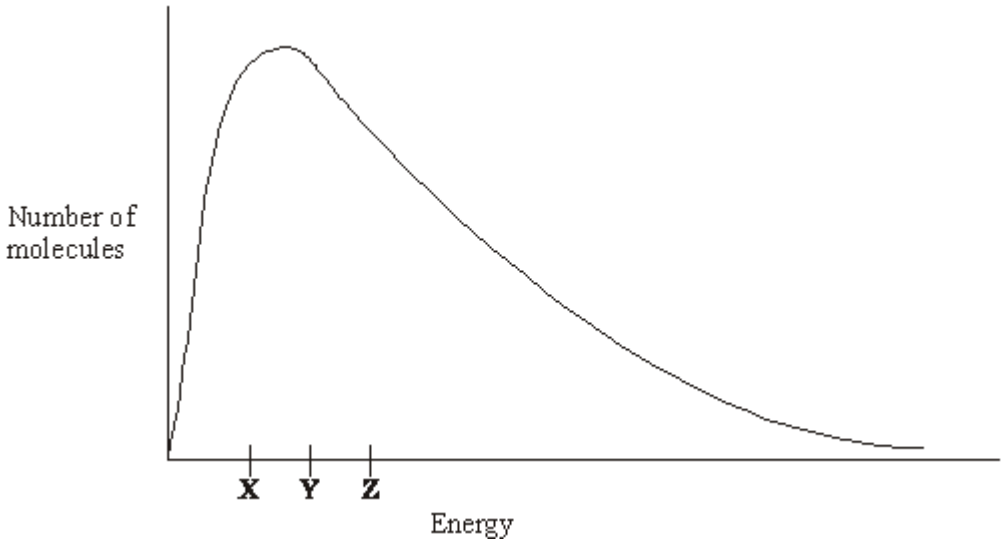
Q1. The diagram below shows the Maxwell–Boltzmann distribution of molecular energies in a sample of a gas.



(a) (i) State which one of **X**, **Y** or **Z** best represents the mean energy of the molecules.

.....

(ii) Explain the process that causes some molecules in this sample to have very low energies.

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(3)

(b) On the diagram above, sketch a curve to show the distribution of molecular energies in the same sample of gas at a higher temperature.

(2)

(c) (i) Explain why, even in a fast reaction, a very small percentage of collisions leads to a reaction.

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(ii) Other than by changing the temperature, state how the proportion of successful collisions between molecules can be increased. Explain why this method causes an increase in the proportion of successful collisions.

Method for increasing the proportion of successful collisions .....

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Explanation ….....

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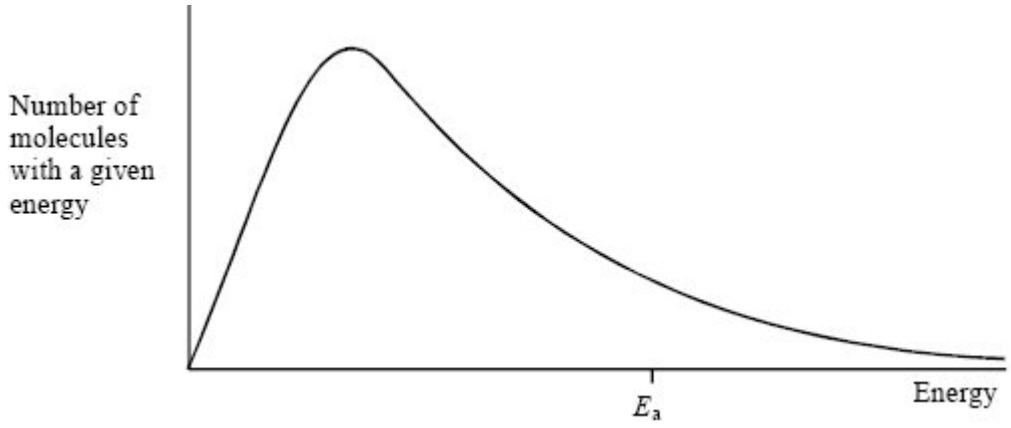
(4)
(Total 9 marks)

Q2. The diagram below shows the Maxwell–Boltzmann energy distribution curve for a sample of gas at a fixed temperature. E_a is the activation energy for the decomposition of this gas.



(a) On this diagram sketch the distribution curve for the same sample of gas at a higher temperature.

(3)

(b) (i) What is the effect of an increase in temperature on the rate of a chemical reaction?
Explain your answer with reference to the Maxwell–Boltzmann distribution.

Effect .....

Explanation .....

.....

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(ii) What is the effect of the addition of a catalyst on the rate of a chemical reaction?
Explain your answer with reference to the Maxwell–Boltzmann distribution.

Effect .....

Explanation .....

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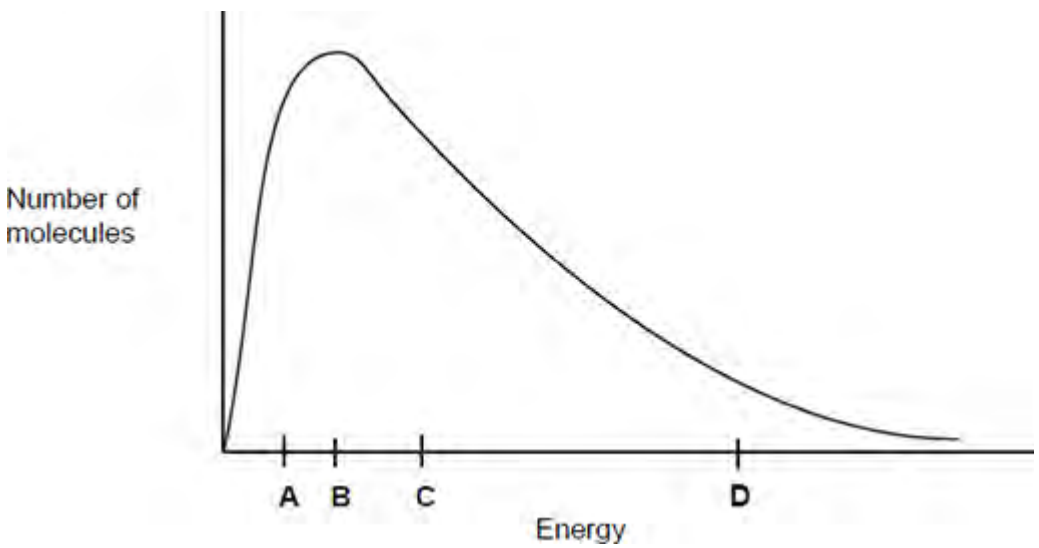
(6)
(Total 9 marks)

Q3. This question is about the Maxwell–Boltzmann distribution of molecular energies in a sample of a gas shown in the figure below.



Which letter best represents the mean energy of the molecules?

A ⬭

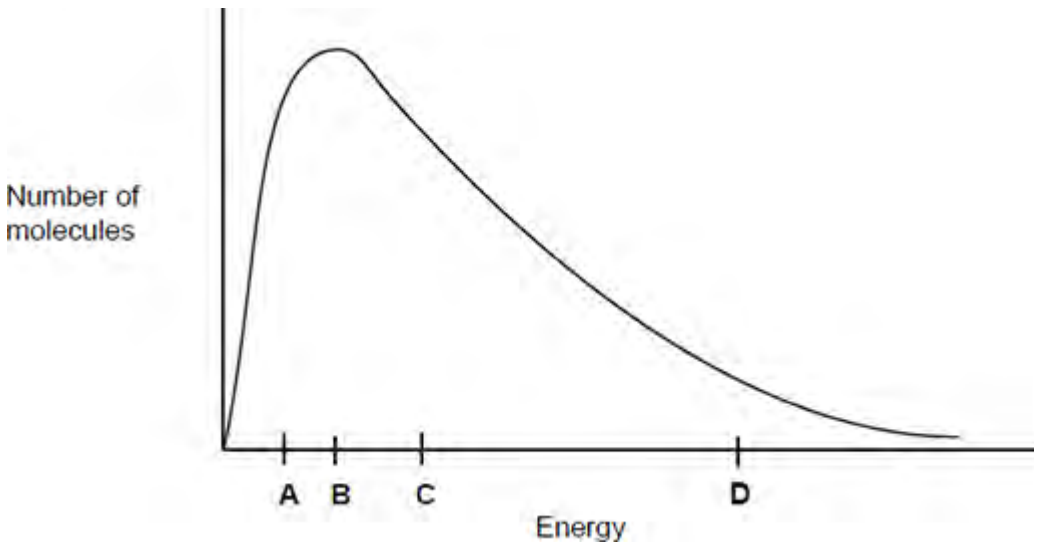
B ⬭

C ⬭

D ⬭

(Total 1 mark)

Q4. This question is about the Maxwell–Boltzmann distribution of molecular energies in a sample of a gas shown in the following figure.



What does the area under the curve represent?

A The total energy of the particles. ⬭

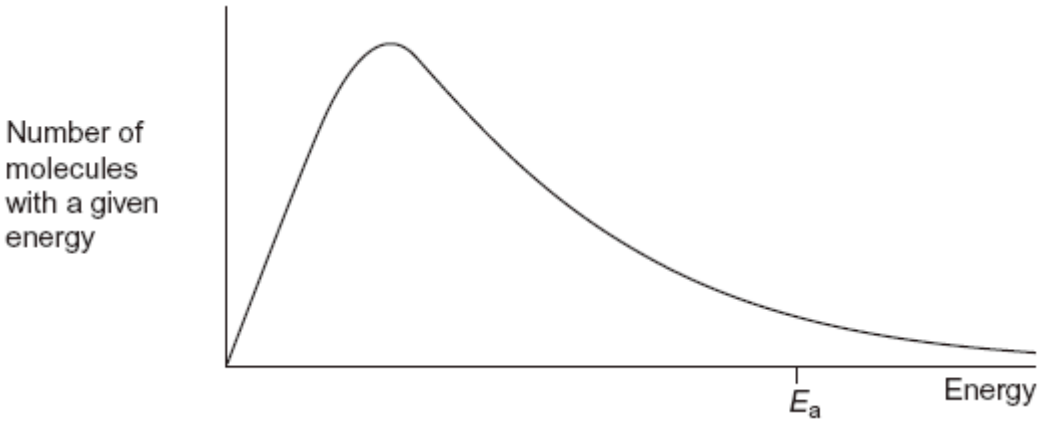
B The total number of particles. ⬭

C The number of particles that can react with each other. ⬭

D The total number of particles that have activation energy. ⬭

(Total 1 mark)

Q5. The diagram below shows a Maxwell–Boltzmann distribution for a sample of gas at a fixed temperature.
E_a is the activation energy for the decomposition of this gas.



(a) (i) On this diagram, sketch the distribution for the same sample of gas at a higher temperature.

(2)

(ii) With reference to the Maxwell–Boltzmann distribution, explain why an increase in temperature increases the rate of a chemical reaction.

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(2)

(b) Dinitrogen oxide (N_2O) is used as a rocket fuel. The data in the table below show how the activation energy for the decomposition of dinitrogen oxide differs with different catalysts.

$$2N_2O(g) \longrightarrow 2N_2(g) + O_2(g)$$

	Ea / kJ mol^{-1}
Without a catalyst	245
With a gold catalyst	121
With an iron catalyst	116
With a platinum catalyst	136

(i) Use the data in the table to deduce which is the most effective catalyst for this

decomposition.

.....

(1)

(ii) Explain how a catalyst increases the rate of a reaction.

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(2)
(Total 7 marks)

Q6. The rate of a chemical reaction is influenced by the size of the activation energy. Catalysts are used to increase the rates of chemical reactions but are not used up in the reactions.

(a) Give the meaning of the term *activation energy*.

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(2)

(b) Explain how a catalyst increases the rate of a reaction.

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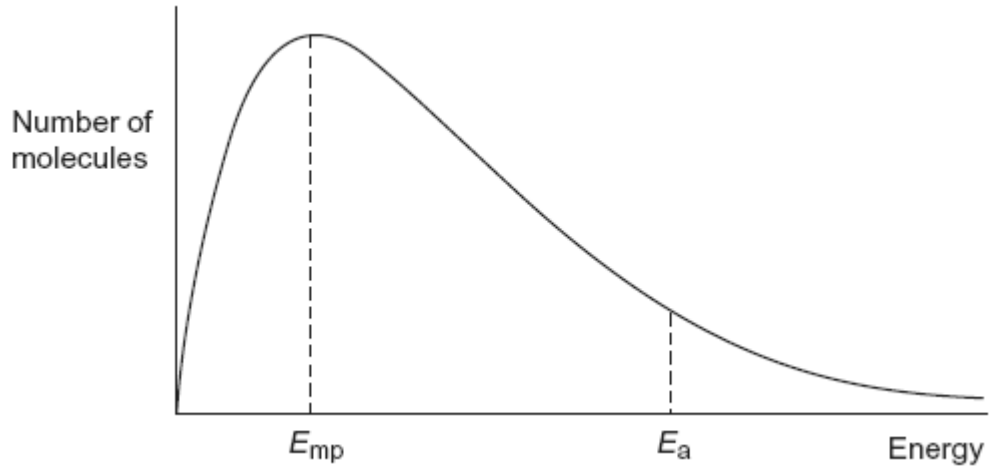
(2)

(c) The diagram below shows the Maxwell–Boltzmann distribution of molecular energies, at a constant temperature, in a gas at the start of a reaction.
On this diagram the most probable molecular energy at this temperature is shown by the symbol E_{mp}
The activation energy is shown by the symbol E_a



To answer the questions (c)(i) to (c)(iv), you should use the words **increases**, **decreases** or **stays the same**. You may use each of these answers once, more than once or not at all.

(i) State how, if at all, the value of the most probable energy (E_{mp}) changes as the total number of molecules is increased at constant temperature.

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(1)

(ii) State how, if at all, the number of molecules with the most probable energy (E_{mp}) changes as the temperature is decreased without changing the total number of molecules.

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(1)

(iii) State how, if at all, the number of molecules with energy greater than the activation energy (E_a) changes as the temperature is increased without c hanging the total number of molecules.

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(1)

(iv) State how, if at all, the area under the molecular energy distribution curve changes as a catalyst is introduced without changing the temperature or the

total number of molecules.

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(1)

(d) For each of the following reactions, identify a catalyst and name the organic product of the reaction.

(i) The fermentation of an aqueous solution of glucose.

Catalyst .....

Name of organic product .....

.....

(2)

(ii) The hydration of but-2-ene.

Catalyst .....

Name of organic product .....

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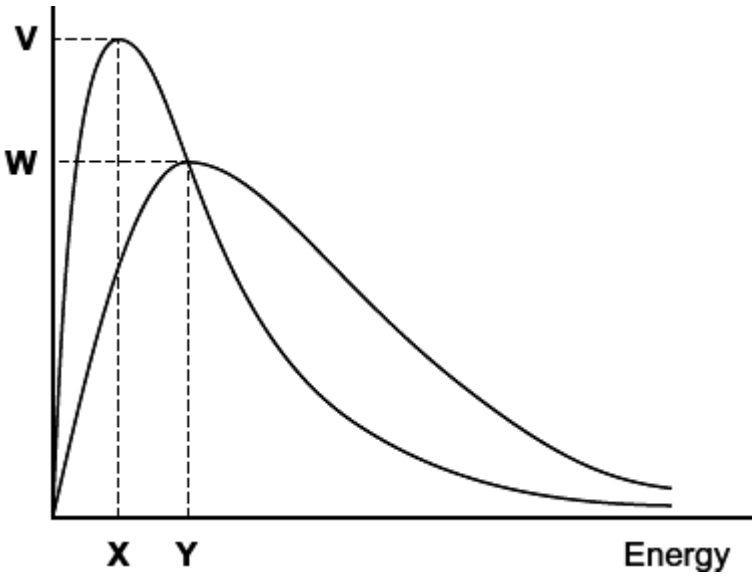
(2)

(Total 12 marks)

Q7. The diagram shows the Maxwell-Boltzmann distribution of molecular energies in a gas at two different temperatures.



(a) One of the axes is labelled. Complete the diagram by labelling the other axis.

(1)

(b) State the effect, if any, of a solid catalyst on the shape of either of these distributions.

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(1)

(c) In the box, write the letter, **V**, **W**, **X** or **Y**, that represents the most probable energy of the molecules at the lower temperature.

(1)

(d) Explain what must happen for a reaction to occur between molecules of two different gases.

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(2)

(e) Explain why a small increase in temperature has a large effect on the initial rate of a reaction.

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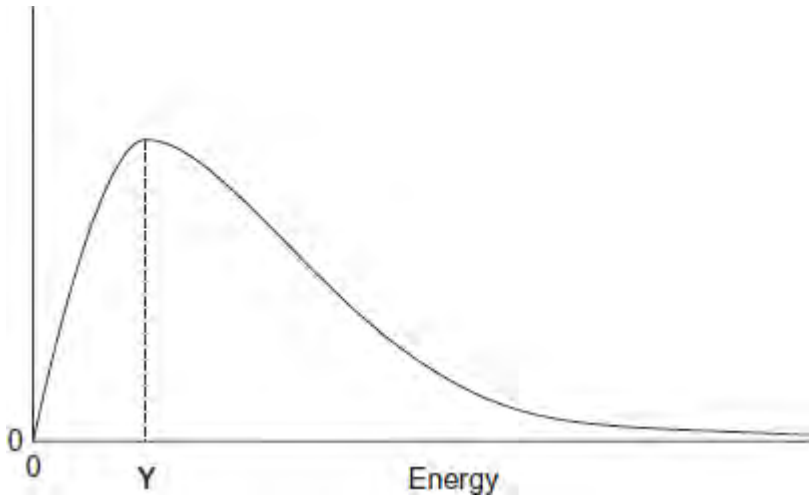
(1)

(Total 6 marks)

Q8. The following figure shows the Maxwell.Boltzmann distribution of molecular energies in a sample of gas at temperature *T*.



(a) One of the axes is labelled.
Label the other axis.

(1)

(b) State why the curve starts at the origin.

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(1)

(c) Which of the following, **A**, **B** or **C**, describes what the value of **Y** represents in the figure?
Write the correct letter, **A**, **B** or **C**, in the box.

A The energy needed for a successful collision
B The minimum energy needed for a reaction to occur
C The most probable energy

(1)

(d) On the figure above, draw a distribution of molecular energies in this sample of gas at a **higher** temperature.

(2)

(e) The pressure of the original sample of gas is doubled at temperature *T*.

State the effect, if any, of this change on the value of **Y**.

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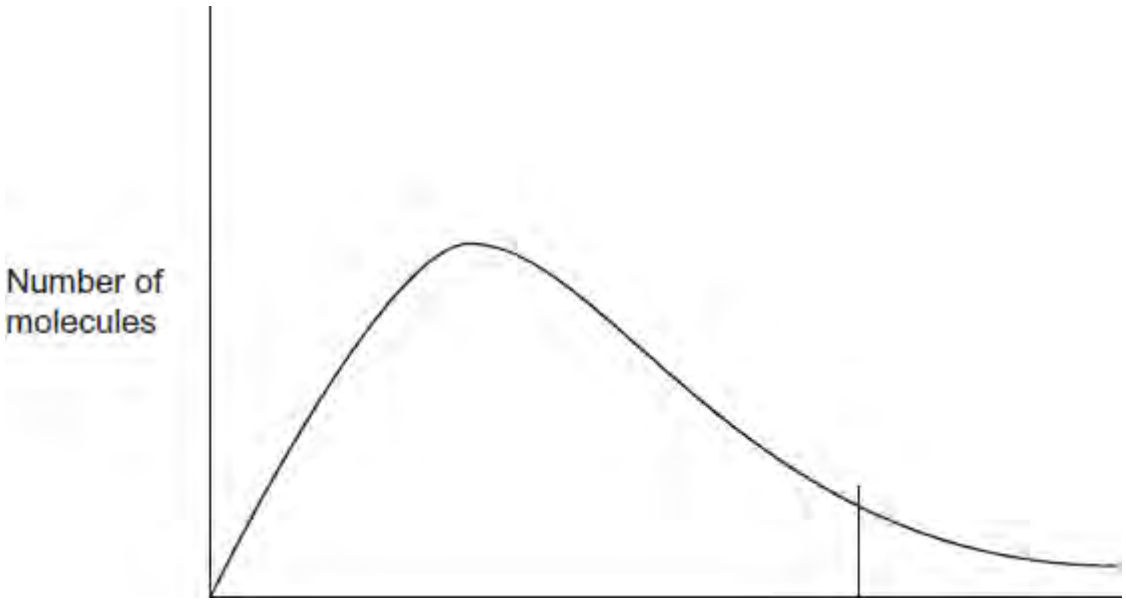
(1)
(Total 6 marks)

Q9. The diagram shows the Maxwell–Boltzmann distribution for a sample of gas at a fixed temperature.
E_a is the activation energy for the decomposition of this gas.



E_{mp} is the most probable value for the energy of the molecules.

(a) On the appropriate axis of this diagram, mark the value of E_{mp} for **this** distribution.

On this diagram, sketch a new distribution for the same sample of gas at a **lower** temperature.

(3)

(b) With reference to the Maxwell–Boltzmann distribution, explain why a decrease in temperature decreases the rate of decomposition of this gas.

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(2)
(Total 5 marks)