Practice Questions Topic 6 Kinetics *[79 marks]*

1. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

2. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

3. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

4. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

5. *[1 mark]*

Markscheme

A

Examiners report

There was a concern about the use of the word “can” in the question stem. The word was used to make the question about reactions in general. It does not seem to have troubled the candidates; it was the seventh easiest question, answered correctly by nearly 80% of the candidates.

6.

[1 mark]

Markscheme

B

Examiners report

[N/A]

7.

[1 mark]

Markscheme

D

Examiners report

Although one respondent was concerned about the circles being confused with bubbles and the use of the word “pellet”, this turned out to be the easiest question on the paper. “Pellet” is a word that the examiners would expect candidates to understand.

8.

[1 mark]

Markscheme

A

Examiners report

[N/A]

9.

[1 mark]

Markscheme

A

Examiners report

It was suggested by one respondent that increase of pressure might be ambiguous. In the guide, the effect of pressure on the rate of a reaction is mentioned in AS 6.2.4. 59% of candidates got this question correct.

10.

[1 mark]

Markscheme

B

Examiners report

Two respondents stated that this question was somewhat misleading. The question was one of the more challenging questions on the paper but 51.70% of candidates did get B. as the correct answer.

11.

[1 mark]

Markscheme

A

Examiners report

[N/A]

12.

[1 mark]

Markscheme

B

Examiners report

[N/A]

13.

[1 mark]

Markscheme

C

Examiners report

There were two G2 comments on this question both of which stated that this was a difficult question at SL. The question certainly was challenging and was found to be the third hardest question on the paper. However, 49% of candidates did manage to get the correct answer, C.

14.

[1 mark]

Markscheme

D

Examiners report

[N/A]

15.

[1 mark]

Markscheme

D

Examiners report

The fact that the state of the reactants is inevitably linked to the frequency of collisions between particles appeared to cause a degree of confusion as to whether they were separate factors and as a result the question also proved a poor discriminator, with a discrimination index of 0.04. A decision was therefore taken to omit it from the total mark.

16.

[1 mark]

Markscheme

C

Examiners report

Opinion expressed through the G2 forms was divided with some commenting that this was a good question, whilst others felt it was too time consuming. Though a significant number of blank responses would seem to indicate that some candidates found the format of the question confusing, those that answered it performed quite well as indicated by a difficulty index of 44%. The question also proved to be quite a good discriminator, with a discrimination index of 0.33.

17.

[1 mark]

Markscheme

D

Examiners report

[N/A]

18a.

[1 mark]

Markscheme

decrease in concentration/mass/amount/volume of reactant with time / increase in concentration/mass/amount/volume of product with time / change in concentration/mass/amount/volume of reactant/product with time;

Examiners report

Surprisingly, the rate of reaction was only correctly defined by approximately 50% of candidates in (a) (i).

18b.

[1 mark]

Markscheme

$\mathrm{MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)}$;

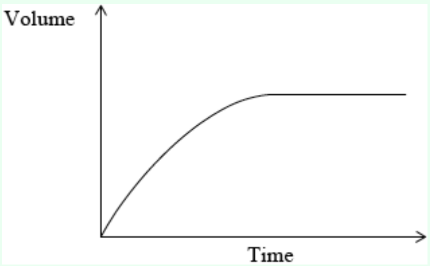
Ignore state symbols.

Examiners report

The equation for the reaction of magnesium carbonate with dilute hydrochloric acid was not well answered (part (ii)), and often candidates did not write correct formula or forgot to include water as a product.

18c. *[1 mark]*

Markscheme



;

Plot starts at the origin and levels off.

No mark awarded if axes are not labelled.

Examiners report

Part (iii) was well answered by most candidates.

18d. *[4 marks]*

Markscheme

new curve reaches same height as original curve;

new curve less steep than original curve;

volume of gas produced is the same because the same amount of acid is used;

reaction is slower because concentration is decreased;

Examiners report

Part (iv) was well answered by most candidates, although the weaker candidates often only scored two or three marks.

18e. *[4 marks]*

Markscheme

(from experiments 1 and 2 at constant $[H_2]$), [NO] doubles, rate quadruples;

hence, second order with respect to NO;

(from experiments 2 and 3 at constant [NO]), $[H_2]$doubles, rate doubles;

first order with respect to H_2;

Allow alternative mathematical deductions also.

Examiners report

Part (b) (i) was well answered and many candidates scored all four marks. Some candidates used a simple mathematical approach and those that followed this method typically were able to deduce the order correctly.

18f. *[1 mark]*

Markscheme

$\text{rate} = k[\text{NO}]^2[\text{H}_2]$;

Examiners report

For (ii) most candidates were able to write the rate expression for the reaction.

18g. *[2 marks]*

Markscheme

$k\left(= (10.00 \times 10^{-5})/(10.00 \times 10^{-3})^2(4.00 \times 10^{-3})\right) = 2.50 \times 10^2$;

Do not penalize if Experiments 1 or 2 are used to determine k.

$\text{mol}^{-2}\text{dm}^6\text{s}^{-1}$;

Examiners report

In (iii), determining the value of the rate constant and its corresponding units was difficult for many candidates and only the better candidates scored both marks. Many mistakes were seen in the units.

18h. *[1 mark]*

Markscheme

step 1 / equation showing step 1;

Examiners report

Part (c) (i) was usually well answered.

18i. *[1 mark]*

Markscheme

O (atom) / oxygen atom;

Do not allow oxygen or O_2.

Examiners report

A common mistake for (ii) involved candidates writing O_2 instead of O.

18j. *[1 mark]*

Markscheme

(minimum) energy needed for a reaction to occur / difference in energy between the reactants and transition state;

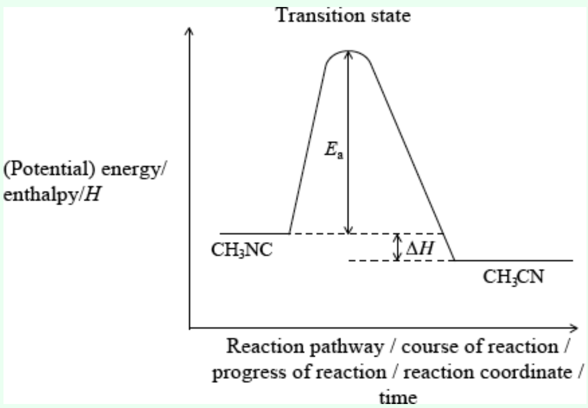
Examiners report

The definition of activation energy was well answered.

18k.

[3 marks]

Markscheme



correct position of activation energy;

correct position of ΔH **and** $H(\mathrm{CH_3NC})$/reactant line above $H(\mathrm{CH_3CN})$ product line;

Accept ΔE instead of ΔH on diagram if y-axis is labelled as energy.

Do not penalize if CH_3NC and CH_3CN are not labelled on diagram.

correct position of transition state;

*Allow **[2 max]** if axes are not labelled on diagram.*

Examiners report

Part (ii) was a question where most candidates scored at least one/two marks although perfect answers were less common. Reasons leading to the loss of marks included: absence of axes, incomplete libelling of axes and the incorrect identification of the position of the transition state.

18l.

[1 mark]

Markscheme

as temperature/T increases rate constant/k increases (exponentially);

Examiners report

Parts (iii) and (iv) were very poorly answered for such a fundamental topic. All sorts of errors were evident, including incorrect gradients, inability to rearrange the Arrhenius Equation etc.

18m.

[4 marks]

Markscheme

from graph gradient $m = -\frac{E_a}{R}$;

measurement of gradient from chosen points on graph;

Units of m are K. Do not penalize if not given, but do not award mark for incorrect units.

Value of m is based on any two suitable points well separated on the plot.

correct answer for E_a;

correct units corresponding to answer;

Note: *A typical answer for $E_a = 1.6 \times 10^2$ kJ / kJ mol^{-1}.*

Examiners report

Even the better candidates struggled greatly with this question, even though this comes straight from AS 16.3.2.

19.

[1 mark]

Markscheme

C

Examiners report

[N/A]

20.

[1 mark]

Markscheme

D

Examiners report

[N/A]

21.

[8 marks]

Markscheme

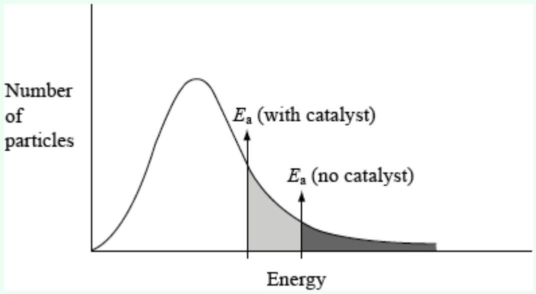
(a) $[I_2]$ does not affect rate / *OWTTE*;

neither correct/both partially correct with explanation as to how;

(b) more particles/molecules have sufficient energy to overcome activation energy / *OWTTE*;

more frequent collisions;

(c) (i)



axes correctly labelled *x* = energy/velocity/speed, *y* = number/% of molecules/particles;

graph showing correct curve for Maxwell-Boltzmann distribution;

If two curves are drawn, first and second mark can still be scored, but not third.

Curve(s) must begin at origin and not go up at high energy.

two activation energies shown with *E*cat shown lower;

Award the mark for the final point if shown on an enthalpy level diagram.

(ii) catalyst provides an alternative pathway of lower energy / *OWTTE*;

Accept catalyst lowers activation energy (of reaction).

Examiners report

Most of the G2 comments on this question predicted the downfalls in the performance of the candidates. Q2 proved to be poorly answered overall with virtually no candidate scoring full marks. In (a), often the question was not addressed accurately. It appeared that some candidates interpreted the question to imply that one of the hypotheses was correct. Many candidates did however score at least one mark for stating that the concentration of iodine did not affect the rate. In (b), candidates typically understood the basics of the concept. However, the most common error was candidates stating that there are more collisions instead of stating that there are more frequent collisions i.e. some reference to time had to be given which has been commented extensively previously in subject reports. In (c), very few candidates knew how to draw a Maxwell-Boltzmann distribution curve which was very surprising, as this is securely on-syllabus. Many candidates drew an enthalpy-level diagram, others drew two curves and many dropped marks for incorrectly labelled axes or poorly sketched curves. For the latter, the most common mistakes involved symmetric curves, curves not starting at the origin or crossing the *x*-axis at high energy. In contrast however, (c) (ii) was very well answered with most candidates stating that a catalyst provides an alternative pathway of lower energy. Some candidates stated that a catalyst lowers the activation energy which was also accepted.

22.

[1 mark]

Markscheme

A

Examiners report

[N/A]

23.

[1 mark]

Markscheme

D

Examiners report

[N/A]

24.

[1 mark]

Markscheme

A

Examiners report

One respondent commented that it “is more difficult than it might be because of the use of algebra symbols”. This was the fourth easiest question with nearly 84% giving the correct answer.

25.

[1 mark]

Markscheme

D

Examiners report

Some respondents mentioned in their G2 forms that the question was not appropriate as they could not find in the syllabus details where the specific relationship between temperature in K and average kinetic energy of molecules of gas is mentioned. In assessment statement 6.2.1 in the syllabus details it is clearly stated that “average kinetic energy is proportional to temperature in kelvins”. 48.33% of the candidates chose the correct answer D. The discrimination index for this question was 0.42 which is reasonably good.

26.

[1 mark]

Markscheme

B

Examiners report

[N/A]

27.

[1 mark]

Markscheme

A

Examiners report

[N/A]

28a.

[1 mark]

Markscheme

KI/I^-/potassium iodide/iodide (ion) (rapidly) reformed (in second stage of reaction);

Examiners report

This question explored basic chemical concepts in the context of a practical situation. Whilst this is one frequently carried out during practical courses, none of the questions depended on prior knowledge. Students varied significantly in their ability to interpret the information given to answer parts (a) to (c), but very few could correctly carry out the propagation of uncertainties required in part (d). An encouraging number were able to carry out the rate calculation required in part (e). It was surprising how many students, though unable to identify the axes of the Arrhenius graph given in part (f), were still able to interpret it to correctly calculate the activation energy. Part (g) was deliberately open ended and elicited a number of interesting responses, though frequently the tests proposed would not in fact confirm the suggested hypothesis.

28b. *[2 marks]*

Markscheme

amount (in mol) of H_2O_2/hydrogen peroxide $\gg$ amount (in mol) $Na_2S_2O_3/S_2O_3^{2-}$/sodium thiosulfate/ thiosulfate (ion);

Accept amount (in mol) of H_2O_2/hydrogen peroxide
$\gg$ amount (in mol) KI/I^-/potassium iodide/iodide (ion).

Accept "H_2O_2/hydrogen peroxide is in (large) excess/high concentration".

(at end of reaction) $[H_2O_2]$ is only slightly decreased/virtually unchanged;

Examiners report

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28c. *[2 marks]*

Markscheme

all $Na_2S_2O_3$/sodium thiosulfate/$S_2O_3^{2-}$/thiosulfate consumed/used up;

Accept "iodine no longer converted to iodide".

(free) iodine is formed / iodine reacts with starch / forms iodine-starch complex;

Examiners report

This question explored basic chemical concepts in the context of a practical situation. Whilst this is one frequently carried out during practical courses, none of the questions depended on prior knowledge. Students varied significantly in their ability to interpret the information given to answer parts (a) to (c), but very few could correctly carry out the propagation of uncertainties required in part (d). An encouraging number were able to carry out the rate calculation required in part (e). It was surprising how many students, though unable to identify the axes of the Arrhenius graph given in part (f), were still able to interpret it to correctly calculate the activation energy. Part (g) was deliberately open ended and elicited a number of interesting responses, though frequently the tests proposed would not in fact confirm the suggested hypothesis.

28d. *[4 marks]*

Markscheme

total volume $0.100\ (\mathrm{dm}^3)/100\ (\mathrm{cm}^3)$;

$\left(\text{change in concentration } = \frac{1.00\times10^{-4}}{0.100} =\right)\ 1.00\times10^{-3}\ (\mathrm{mol\,dm}^3)$;

$\left(\text{rate} = \frac{1.00\times10^{-3}}{45} =\right)\ 2.2\times10^{-5}$;

*Award **[3]** for the correct final answer.*

$\mathrm{mol\,dm^{-3}s^{-1}}$;

Examiners report

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28e. *[2 marks]*

Markscheme

x-axis: $\frac{1}{\text{Temperature}}/\frac{1}{T}/\mathrm{T}^{-1}$;

Ignore units.

y-axis: ln rate/$\log_e$ rate / ln rate constant/$\log_e$ rate constant / ln k/$\log_e k$;

Examiners report

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28f. *[3 marks]*

Markscheme

gradient $= \frac{-E_a}{R}$;

gradient $= \frac{-4.00}{(3.31\times10^{-3}-2.83\times10^{-3})} = -8333/ = \frac{-4.80}{(3.41\times10^{-3}-2.83\times10^{-3})} = -8276$;

$E_a = \left(\frac{8.31\times8333}{1000}\right) = 69.3\ (\mathrm{kJ\,mol^{-1}})/ = \left(\frac{8.31\times8276}{1000}\right) = 68.8\ (\mathrm{kJ\,mol^{-1}})$;

*Award **[3]** for correct final answer.*

Accept values from 65.0 to 73.0 kJ mol^{-1}.

*Deduct **[1]** for final answer in J mol^{-1}.*

*Deduct **[1]** for final answer not to 3 significant figures.*

Examiners report

This question explored basic chemical concepts in the context of a practical situation. Whilst this is one frequently carried out during practical courses, none of the questions depended on prior knowledge. Students varied significantly in their ability to interpret the information given to answer parts (a) to (c), but very few could correctly carry out the propagation of uncertainties required in part (d). An encouraging number were able to carry out the rate calculation required in part (e). It was surprising how many students, though unable to identify the axes of the Arrhenius graph given in part (f), were still able to interpret it to correctly calculate the activation energy. Part (g) was deliberately open ended and elicited a number of interesting responses, though frequently the tests proposed would not in fact confirm the suggested hypothesis.

28g.

[2 marks]

Markscheme

acting as a catalyst / black powder reacts with thiosulfate ions / solid dissolves to give blue-black solution;

Accept any other valid suggestion which will make colour change more rapid.

For catalyst: amount/mass of black powder remains constant / no new/different products formed / activation energy decreased;

For other suggestions: any appropriate way to test the hypothesis;

*Award **[1]** for valid hypothesis, **[1]** for appropriate method of testing the stated hypothesis.*

Examiners report

This question explored basic chemical concepts in the context of a practical situation. Whilst this is one frequently carried out during practical courses, none of the questions depended on prior knowledge. Students varied significantly in their ability to interpret the information given to answer parts (a) to (c), but very few could correctly carry out the propagation of uncertainties required in part (d). An encouraging number were able to carry out the rate calculation required in part (e). It was surprising how many students, though unable to identify the axes of the Arrhenius graph given in part (f), were still able to interpret it to correctly calculate the activation energy. Part (g) was deliberately open ended and elicited a number of interesting responses, though frequently the tests proposed would not in fact confirm the suggested hypothesis.

29.

[1 mark]

Markscheme

C

Examiners report

The initial wording of the question was thought to be complicated, though it was clear that a catalyst had been added (only possible answer here).

30.

[1 mark]

Markscheme

B

Examiners report

There were a number of comments suggesting that the sentence “A catalyst creates a new reaction pathway of lower activation energy.” should have been used. The examiners accept the rebuke. Nevertheless, nearly 85% of the candidates saw past the poor wording and gave B as the correct answer.

31.

[1 mark]

Markscheme

C

Examiners report

[N/A]

32.

[1 mark]

Markscheme

C

Examiners report

[N/A]

33.

[1 mark]

Markscheme

A

Examiners report

[N/A]