AP® Chemistry
2004 Sample Student Responses
Form B

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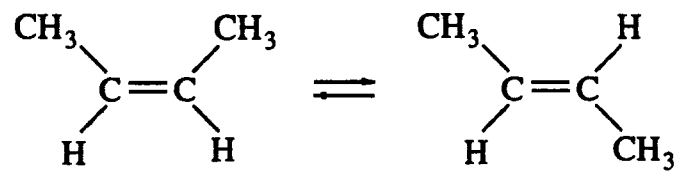

cis-2-butene *trans*-2-butene

8. The gas-phase conversion reaction between the geometric isomers *cis*-2-butene and *trans*-2-butene is represented by the equation above. The value of the equilibrium constant, K_{eq}, for the reaction is 3.2 at 298 K and 1.0 atm.

   (a) In a mixture of the isomers at equilibrium at 298 K and 1.0 atm, which is present at a higher concentration, *cis*-2-butene or *trans*-2-butene? Justify your answer.

   (b) If 1.00 mol of pure *cis*-2-butene and 1.0 mol of pure *trans*-2-butene were introduced into an evacuated container at 298 K, in which direction (to the right or to the left) would the reaction proceed to establish equilibrium? Justify your answer.

   (c) Given that K_{eq} for the reaction at 400 K has the value 1.3, predict whether the reaction is endothermic or exothermic. Justify your answer.

   (d) There are other structural isomers of *cis*-2-butene and *trans*-2-butene. Draw one of these isomers, including all atoms, and give its IUPAC name.

(a) $K_c = 3.2$ since $K_c > 1 \Rightarrow$ [products] > [reactants]
$\Rightarrow$ [trans-2-butane] presents at a higher concentration at equilibrium.

(b) To the right, because $K_c = \frac{[\text{trans-2-butane}]}{[\text{cis-2-butane}]}$

(the volumes are the same) $= \frac{n_{\text{trans-2-butane}}}{n_{\text{cis-2-butane}}}$

$= \frac{1}{1} = 1 < K$

$\Rightarrow$ to increase $K \Rightarrow$ the reaction shifts to the products.

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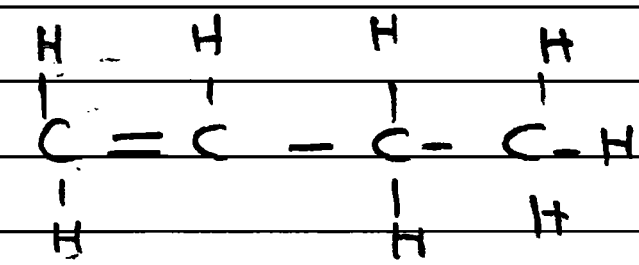
(c) (at 400 K K_{eq}) < (K_{eq} at 298 K)

the reaction is exothermic because when we increase the temperature K_{eq} decreases ⟹ the reaction shifts to the left direction (the products) ⟹ Heat is in the products ($\Delta H < 0$) ⟹ exothermic process.

(d) formula (C_4H_8) ⟹



8 → It is 1- butene

END OF EXAMINATION

IF YOU FINISH PART B OF SECTION II BEFORE TIME IS CALLED, YOU MAY RETURN TO PART A OF SECTION II IF YOU WISH, BUT YOU MAY NOT USE A CALCULATOR.

THE FOLLOWING INSTRUCTIONS APPLY TO THE BACK COVER OF THE SECTION II BOOKLET.

- **CIRCLE THE NUMBERS OF THE FREE-RESPONSE QUESTIONS YOU ANSWERED AS REQUESTED ON THE BOTTOM OF THE BACK PAGE.**
- **MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE BACK OF THE SECTION II BOOKLET.**
- **CHECK TO SEE THAT YOUR AP NUMBER APPEARS IN THE BOX(ES) ON THE BACK COVER.**
- **MAKE SURE YOU HAVE USED THE SAME SET OF AP NUMBER LABELS ON ALL AP EXAMINATIONS YOU HAVE TAKEN THIS YEAR.**

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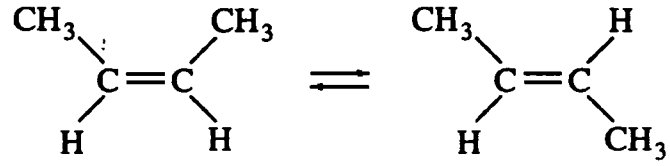

cis-2-butene *trans*-2-butene

8. The gas-phase conversion reaction between the geometric isomers *cis*-2-butene and *trans*-2-butene is represented by the equation above. The value of the equilibrium constant, K_{eq}, for the reaction is 3.2 at 298 K and 1.0 atm.

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   (c) Given that K_{eq} for the reaction at 400 K has the value 1.3, predict whether the reaction is endothermic or exothermic. Justify your answer.

   (d) There are other structural isomers of *cis*-2-butene and *trans*-2-butene. Draw one of these isomers, including all atoms, and give its IUPAC name.

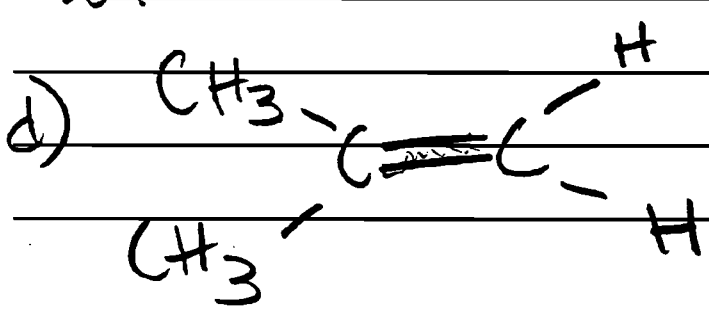
a) At 298K, $K_{eq} > 1$

there will be a higher concentration of trans-2-butene

b) To the right, until Q expression reaches equilibrium.

c) Increase in temp. shifts to the left; heat is absorbed when cis-2-butene is created. Reaction is exothermic as written

d)



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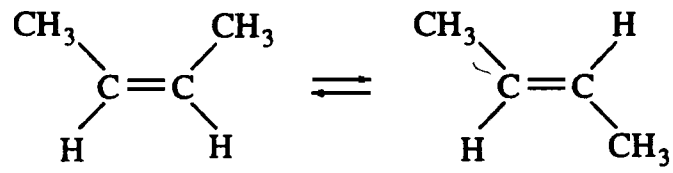

cis-2-butene ⇌ *trans*-2-butene

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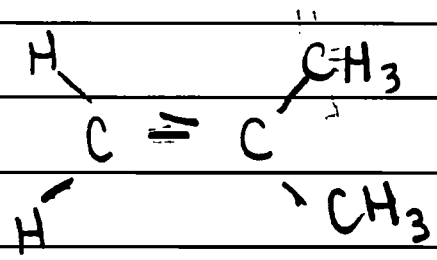
(c) Given that K_{eq} for the reaction at 400 K has the value 1.3, predict whether the reaction is endothermic or exothermic. Justify your answer.

(d) There are other structural isomers of *cis*-2-butene and *trans*-2-butene. Draw one of these isomers, including all atoms, and give its IUPAC name.

(a) Trans-2-butene is present in a higher concentration; the equilibrium constant is greater than 1, indicating that the product would have a larger value for the equation $K_{eq} = \frac{[\text{trans 2 butene}]}{[\text{cis 2 butene}]}$.

(b) The reaction would proceed towards the right, because the K_{eq} value is greater than 1 (the products at equilibrium would have a higher value than the reactants).

(c) The reaction is endothermic, since at a higher temperature the concentration of the product is lower.

(d) 

cis-2-butene

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