K_c CALCULATIONS 2

1 The equilibrium below was established by allowing 2.00 moles of ethanol and 1.00 moles of ethanoic acid to react at 25°C. At equilibrium the mixture contained 0.845 moles of ethyl ethanoate. Calculate K_c at this temperature.

$$CH_3COOH(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3COOCH_2CH_3(l) + H_2O(l)$$

Start	1.00	2.00		
Change	−0.845	−0.845	+0.845	+0.845
✓ End	0.155	1.155	0.845	0.845
[End]	0.155	1.155	0.845	0.845

✓ $K_c = \frac{[ester][H_2O]}{[acid][alcohol]}$

✓ $= \frac{0.845 \times 0.845}{0.155 \times 1.155}$

✓ $= 3.99$

(4)
(A2 BBoF 29)

2 1.90 mol of hydrogen and 1.90 mol of iodine were allowed to reach equilibrium at 710 K. The equilibrium mixture contained 3.00 mol of HI.

Start	1.90	1.90	
	$H_2(g)$ +	$I_2(g)$ ⇌	2 HI(g)
End	0.40	0.40	3.00

a) Write an expression for the equilibrium constant K_c. $K_c = \frac{[HI]^2}{[H_2][I_2]}$ ✓

(1)

b) Calculate the value of the equilibrium constant at 710 K.

$K_c = \frac{\left(\frac{3.00}{V}\right)^2}{\left(\frac{0.40}{V}\right)\left(\frac{0.40}{V}\right)} = 56.3$ ✓ (no units) ✓ ✓

(3)

c) What, if anything, would be effect on the position of the equilibrium of increasing the total pressure?

✓ no effect

(1)
(A2 BBoF 31)

3 a) What is meant by the phrase *dynamic equilibrium*?

✓ both forward + reverse reactions occur simultaneously
✓ at the same rate
✓ concentration of all reactants + products remain constant

(3)

b) What is the difference between a *homogeneous* and a *heterogeneous* equilibrium?

✓ homogeneous: all reactants + products in same phase/state
✓ heterogeneous: " " " " not in same phase/state (2)

c) State Le Châtelier's principle.

if the condition of a system at equilibrium are changed, position of equilibrium moves to oppose change ✓✓ (2)

d) For the equilibrium below what would be the effect on **both** the equilibrium position **and** K_c of the each of the changes below, explaining your reasoning in each case.

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) \qquad \Delta H = -197\ kJ\ mol^{-1}$$

i) What effect would increasing the pressure have?

✓ equilibrium position moves right
✓ to side with less gas molecules to reduce pressure
✓ Kc no change

ii) What effect would increasing the amount of O_2 have?

✓ equilibrium position moves right
✓ to remove added O_2
✓ Kc no effect

iii) What effect would increasing the temperature have?

✓ equilibrium position moves left
✓ in endothermic direction to lower temperature
✓ Kc gets smaller

(9)
(A2 BBoF 23)

4 K_c for the equilibrium below is 7.50 at 50°C. If 50.0 g of ethanol is mixed with 50.0 g of propanoic acid, what mass of ethyl propanoate will be formed at equilibrium?

$$CH_3CH_2OH(l) + CH_3CH_2COOH(l) \rightleftharpoons CH_3CH_2COOCH_2CH_3(l) + H_2O(l)$$

Start	$\frac{50.0}{46.0}$	$\frac{50}{74.0}$			
	1.087	0.676			
Eeq	$1.087-x$	$0.676-x$	x	x	✓

$$K_c = \frac{x^2}{(1.087-x)(0.676-x)} \checkmark$$

$$7.50(1.087-x)(0.676-x) = x^2$$
$$7.50(0.734 - 1.763x + x^2) = x^2$$
$$5.51 - 13.22x + 7.5x^2 = x^2$$
$$6.5x^2 - 13.23x + 5.51 = 0$$

$$x = \frac{13.22 \pm \sqrt{13.22^2 - 4(6.5 \times 5.51)}}{2(6.5)}$$ (4)
(A2 BBoF 38)

$$= \frac{13.22 \pm 5.61}{13.0}$$

$x = 0.585$ ✓ (as $x < 0.66$)

∴ mass ester = 0.585×102.0

$= 59.7\ g$ ✓