Estimate the final volume of a mixture when 34 mL of water is added to 66 mL of ethanol.

```
> restart;
> ρ_W , ρ_EtOH := 1, 0.7893 : # densities in g/
> M_W , M_EtOH := 18.01, 46.07 : # molecular weights in g/mol
  # Values taken from &lt;https://en.wikipedia.org/wiki/Ethanol_(data_page)&gt;
> V_W , V_EtOH := 34, 66 : # volumes in mL
```

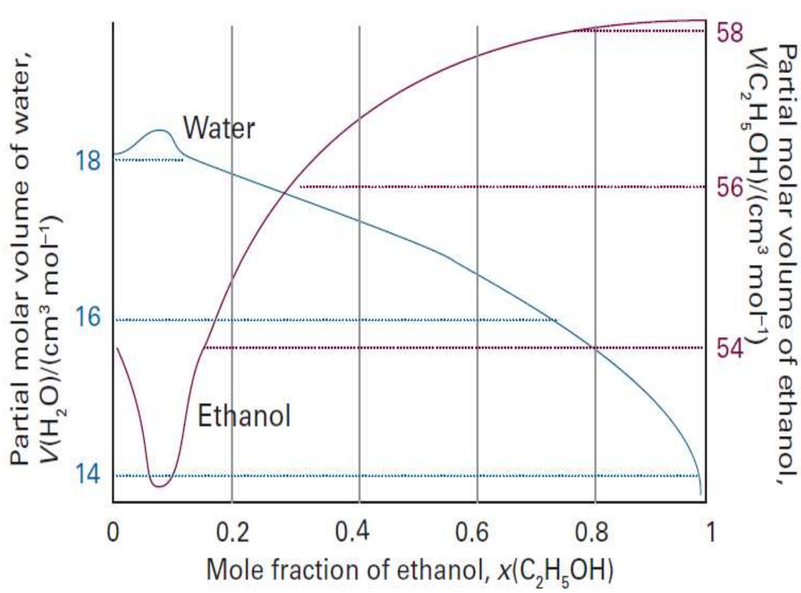
> $n_W := \frac{V_W \cdot \rho_W}{M_W}$: # moles of water

> $n_{EtOH} := \frac{V_{EtOH} \cdot \rho_{EtOH}}{M_{EtOH}}$: # moles of EtOH

> $x_{EtOH} := \frac{n_{EtOH}}{n_{EtOH} + n_W}$; # molar fraction of EtOH

$$0.3746 \quad (1.1)$$

Partial molar volumes of water and ethanol at 25 °C, Atkins p.181



> $V\_W , V\_EtOH := 17.5, 57$: # partial volumes in mL/mol, approximated from the graph

> $V := n_W \cdot V\_W + n_{EtOH} \cdot V\_EtOH$; # total volume of mixture in mL

$$97.4901 \quad (1.2)$$

For a chemical reaction, 3A(g) = 4B (g), calculate the change in the fraction of A molecules dissociated if the reaction pressure is tripled

```
> restart;
> n_A := n·(1 − 3 ·alpha) : # number of moles of A at equilibrium, assuming there are "n" moles of A to begin with
> n_B := 4·alpha·n : # number of moles of B at equilibrium, assuming there are 0 moles of B at the beginning
> x_A := simplify(n_A/(n_A + n_B)); # mol fraction of A
```

$$x_A := \frac{1 - 3\,\alpha}{1 + \alpha} \tag{2.1}$$

```
> x_B := simplify(n_B/(n_A + n_B)); # mol fraction of B
```

$$x_B := \frac{4\,\alpha}{1 + \alpha} \tag{2.2}$$

```
> eq := Kp = (x_B·P)^4/(x_A·P)^3; # equilibrium constant for the reaction
```

$$eq := Kp = \frac{256\,\alpha^4\,P}{(1 + \alpha)\,(1 - 3\,\alpha)^3} \tag{2.3}$$

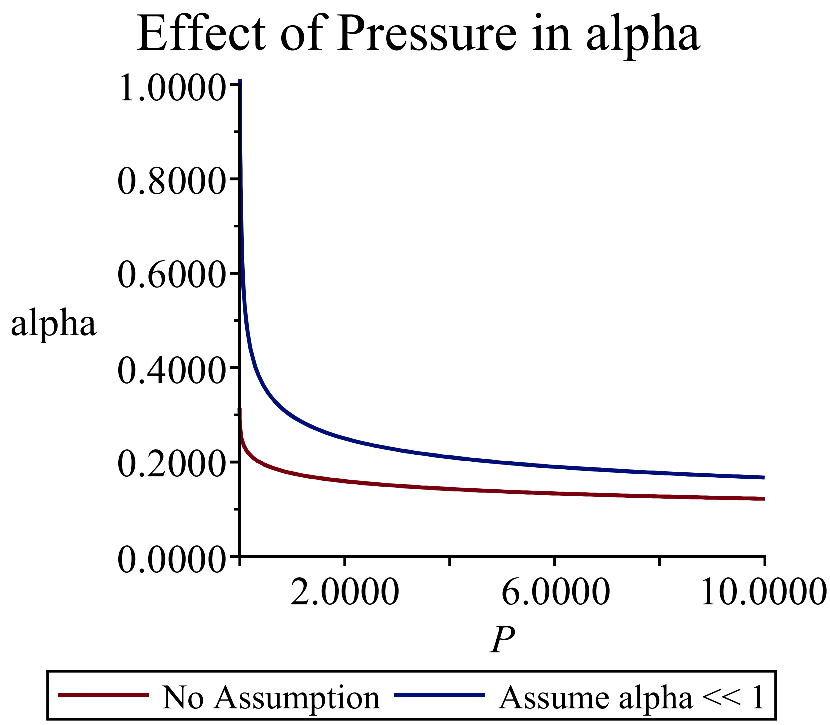
```
> eqS := lhs(eq) = rhs(eq)·(1 + alpha)·(1 − 3·alpha)^3; # by assuming alpha << 1
```

$$eqS := Kp = 256\,\alpha^4\,P \tag{2.4}$$

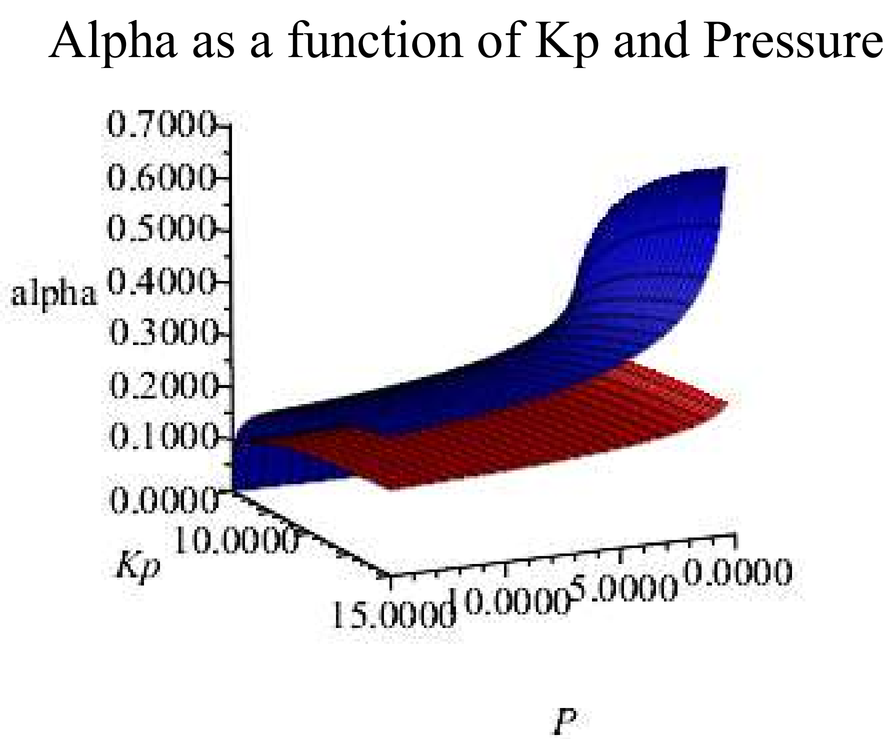
```
> alphaF := solve(eq, alpha, explicit )[3] : # solve for the real, positive solution for alphaF and alphaS
  alphaS := solve(eqS, alpha, explicit )[1]
```

$$alphaS := \frac{\left(\frac{Kp}{P}\right)^{1/4}}{4} \tag{2.5}$$

```
> plots[animate](plot, [[alphaF, alphaS], P], Kp = 0 ..2)
    # letting Kp vary, we plot both alphas
  # we can observe that alpha decreses as P increases, as per Le
    Chatelier's law.
```




```
> # for a more general idea, we can also make a 3 D plot; note
    that it is a mirror image of the plot above for easier
    visualization
  plot3d([alphaF(P, Kp), alphaS(P, Kp)], P = 0 ..15, Kp = 0 ..20, color
    = ["Red", "Blue"])
```



```
> α_2 := subs(P = 3·P, alphaF) : # solve for alpha when the pressure is tripled
> plots[animate](plot, [subs(Kp = rhs(eq), α_2), alpha], P = 0 ..2)
   # letting P vary, we plot the alphas against each other (note that the relationship is not a fuction of P, P just has to be > 0)
```