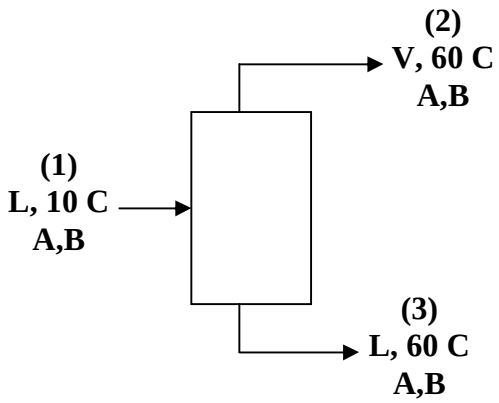
EXAMPLE 5

An equimolar liquid mixture containing A & B at 10 ℃ is separated in a distillation column to a top vapor product containing A=15% and a bottom liquid product containing B=10%. The products exit the distillation column at 60 °C.

Data:

	A	**B**
Cp (gas), J/mol.C°	**32**	**20**
Cp (liquid), J/mol.C°	**12**	**5**
Heat of vaporization (KJ/mol)	**33**	**30**
TB (°C)	**120**	**90**

Calculate the amount of heat that must be supplied to the column to effect the separation.



Degree of Freedom Table

	M.B.	M. & E. B.
P.V.	**6**	**6**
Reactions	**0**	**0**
Temperature	**-**	**3**
Q	**-**	**1**
U	**6**	**10**
M. B. E.	**2**	**2**
E. B. E.	**-**	**1**
Flow	**0**	**0**
Composition	**3**	**3**
Relations	**0**	**0**
Temperature	**-**	**3**
Q	**-**	**0**
I	**5**	**9**
I – U	**-1**	**-1**
Basis	**1**	**1**

From the degree of freedom table it is clear that the material balances can be solved with or without the energy balances. However, the program below is based on both M. & E. balances.

Stream variables (M.B. based)

Stream	1	2	3
P. V.	2	2	2
Given	1y	1y	1y
Remain	1	1	1
Fixed	A1	B2	A3
Defined	B1	A2	B3

EZ SOLVE PROGRAM

```
//        BASIS
NT1 = 100
A1 = 0.5*NT1
//        RELATIONS
B1 = 0.5/0.5*A1
A2 = 15/85*B2
B3 = 10/90*A3
//        M.B.
A1 = A2 + A3
B1 = B2 + B3
//        E.B. DATA
CPGB = 20
CPGA = 32
CPLA = 12
CPLB = 5
HVA = 33000
HVB = 30000
TBA = 120
TBB = 90
T1 = 10
```

T2 = 60
T3 = 60
TR = 25

// REFERENCE A,B(L,25,1)
DH1 = (A1*CPLA + B1*CPLB)*(T1-TR)
DH2A = A2*(CPLA*(TBA-TR) + HVA + CPGA*(T2-TBA))
DH2B = B2*(CPLB*(TBB-TR) + HVB + CPGB*(T2-TBB))
DH2 = DH2A + DH2B
DH3 = (A3*CPLA + B3*CPLB)*(T3-TR)
Q = DH3 + DH2 - DH1

RESULTS (FOR BASIS NT1 = 100)

A1	A2	A3	B1	B2	B3
50	8	42	50	45.3333	4.66667

DH1	DH2	DH2B	DH2A	DH3	Q
-12750	1.605E+06	1.35E+06	257760	18456.7	1.636E+06

CPGA	CPGB	CPLA	CPLB	HVA	HVB
32	20	12	5	33000	30000

T1	T2	T3	TBA	TBB	TR
10	60	60	120	90	25