A4q3

Part a

The randomization performed by randomly assigning treatments to the bolt. Witch means we have ramdon chemical X and chemical y within each bolts.

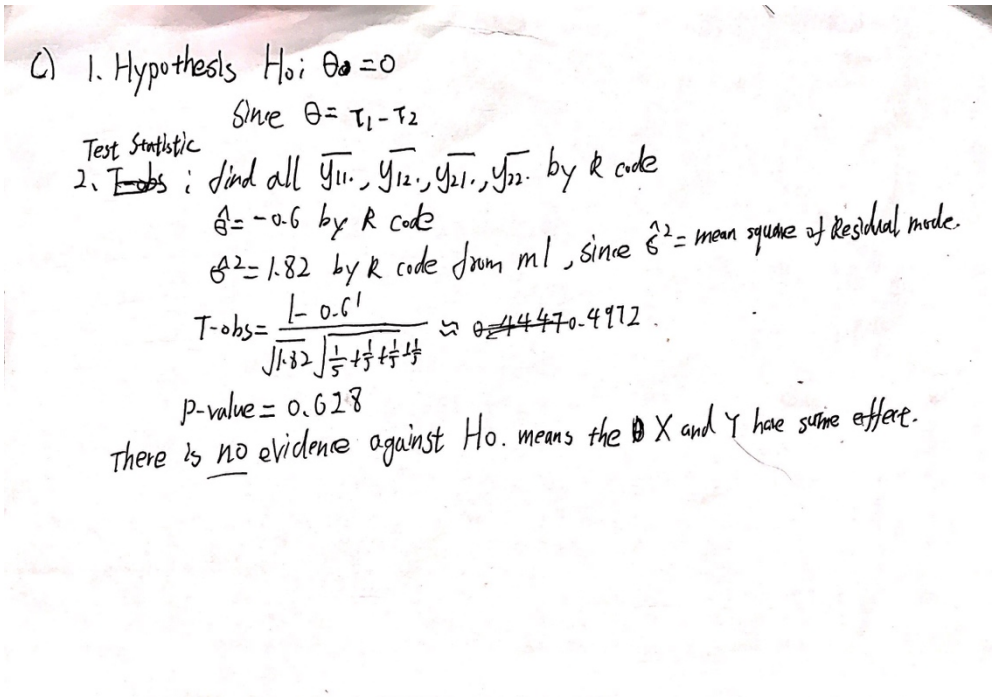
Part b

$$Y_{ijk} = \mu + \alpha_i + \lambda_j + \tau_{ij} + \beta_k + R_{ijk}$$

where mu is the over all mean
alpha is the hemical X effect
lambda is the hemical Y effect
tau is the interaction effect
beta is the Bolt effect
R is the random Error
where i is 1 to ta, ta = 2(# of A); j is 1 to tb, tb = 2(# of B); k is 1 to r, r = 4(# of blcok)
constraints:

$$\sum_{i=1}^{ta} \alpha_i = 0, \sum_{j=1}^{tb} \lambda_j = 0, \sum_{k=1}^{r} \beta_k = 0, \sum_i \tau_{ij} = 0, for \quad \forall i; \sum_j \tau_{ij} = 0, for \quad \forall j$$

Part c



The code is showed in the next page.

```
> q3block =matrix(NA, nrow=4, ncol=5)
> q3block[1,] =c(73,68,74,71,67)
> q3block[2,] =c(73,67,75,72,70)
> q3block[3,] =c(75,68,78,73,68)
> q3block[4,] =c(73,71,75,75,69)
> rownames(q3block) =c('1','2','3','4')
> mu_11 = mean(q3block[1,])
> mu_12 = mean(q3block[2,])
> mu_21 = mean(q3block[3,])
> mu_22 = mean(q3block[4,])
> baths = c(q3block[1,],q3block[2,],q3block[3,],q3block[4,])
> treatment = rep(c(1:4),each = 5)
> treatment = factor(treatment)
> bolt = rep(c(1:5),4)
> bolt = factor(bolt)
> m1 = aov(baths~treatment+bolt)
> summary(m1)
            Df Sum Sq Mean Sq F value   Pr(>F)
treatment    3  12.95    4.32   2.376    0.121
bolt         4 157.00   39.25  21.606 2.06e-05 ***
Residuals   12  21.80    1.82
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> sigma_sq = 1.82
> theta_hat = (mu_11 - mu_12) - (mu_21 - mu_22)
> T_obs = abs(theta_hat) / (sqrt(sigma_sq) * sqrt(4/5))
> T_obs
[1] 0.4972452
> 2*pt(T_obs,df=12,lower.tail = FALSE)
[1] 0.6280016
```

Part d

(i) since the p-value 0.121 > 0.05 (from part(c) code), there is no evidence against H0

(ii) since the p-value 0.6277 > 0.5, there is NO evidence against H0.

Code of part d:

```
> h_x = rep(c('low','high'),each = 10)
> h_y = rep(rep(c('low','high'),each = 5),2)
> m2 = aov(baths~h_x*h_y + bolt)
> summary(m2)
            Df Sum Sq Mean Sq F value   Pr(>F)
h_x          1  11.25   11.25   6.193   0.0285 *
h_y          1   1.25    1.25   0.688   0.4230
bolt         4 157.00   39.25  21.606 2.06e-05 ***
h_x:h_y      1   0.45    0.45   0.248   0.6277
Residuals   12  21.80    1.82
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
>
```