In [39]:
```python
# KNN

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

from sklearn.neighbors import KNeighborsClassifier
from sklearn.preprocessing import StandardScaler
```

In [40]:
```python
# read the data
raw_data = pd.read_csv('winequality-red.csv', sep=';')
```

In [41]:
```python
# remove outliers
for col in raw_data.columns:
        if col != 'quality':
                iqr = raw_data[col].quantile(0.75) - raw_data[col].quantile(
                upper_bound = raw_data[col].quantile(0.75) + 2.5 * iqr
                lower_bound = raw_data[col].quantile(0.25) - 2.5 * iqr
                raw_data = raw_data[(raw_data[col] < upper_bound) & (raw_dat

# save the cleaned data
raw_data.to_csv('cleaned_data.csv', index=False)
```

In [42]:
```python
# raw_data.info()
# remove repeated data
raw_data = raw_data.drop_duplicates()
raw_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1182 entries, 0 to 1598
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype  
---  ------                --------------  -----  
 0   fixed acidity         1182 non-null   float64
 1   volatile acidity      1182 non-null   float64
 2   citric acid           1182 non-null   float64
 3   residual sugar        1182 non-null   float64
 4   chlorides             1182 non-null   float64
 5   free sulfur dioxide   1182 non-null   float64
 6   total sulfur dioxide  1182 non-null   float64
 7   density               1182 non-null   float64
 8   pH                    1182 non-null   float64
 9   sulphates             1182 non-null   float64
 10  alcohol               1182 non-null   float64
 11  quality               1182 non-null   int64  
dtypes: float64(11), int64(1)
memory usage: 120.0 KB
```

In [43]:
```python
raw_data.describe()
```

Out[43]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	tota
count	1182.000000	1182.000000	1182.000000	1182.000000	1182.000000	1182.000000	1182.
mean	8.268613	0.525816	0.260398	2.255118	0.078864	15.692893	45
std	1.674834	0.176989	0.189768	0.545431	0.015813	9.689748	30
min	4.700000	0.120000	0.000000	0.900000	0.038000	1.000000	6.
25%	7.100000	0.390000	0.090000	1.900000	0.069000	8.000000	22.
50%	7.900000	0.520000	0.245000	2.200000	0.078000	14.000000	37.
75%	9.200000	0.640000	0.410000	2.500000	0.088000	21.000000	60.
max	14.300000	1.240000	0.760000	4.300000	0.136000	53.000000	152.

In [44]:

```
# Standardization
scaler = StandardScaler()
raw_data.iloc[:, :-1] = scaler.fit_transform(raw_data.iloc[:, :-1])
```

In [45]:

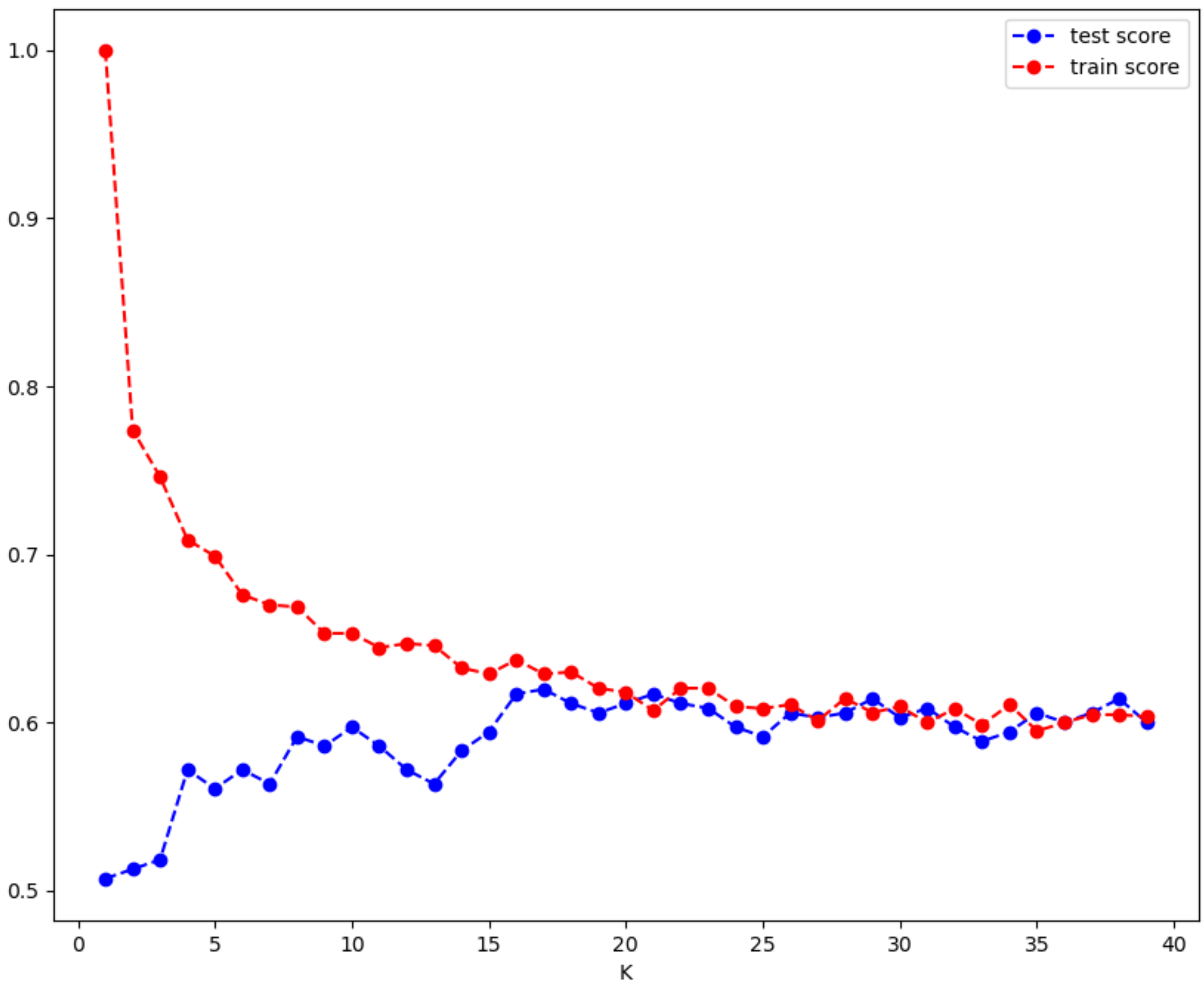
```
# train test split
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(raw_data.iloc[:, :-1], r
```

In [46]:

```
# # gird search on K and distance function
# from sklearn.model_selection import GridSearchCV
# k_range = list(range(1, 50))
# weight_options = ['uniform', 'distance']
# distance_metric = ['euclidean', 'manhattan', 'minkowski', 'cosine']
# param_grid = dict(n_neighbors=k_range, weights=weight_options, metric=dist
# knn = KNeighborsClassifier()
# grid = GridSearchCV(knn, param_grid, cv=10, scoring='accuracy', return_tra
# grid.fit(X_train, y_train)
#
# # print the best parameters
# print(grid.best_params_)
# print(grid.best_score_)
```

In [47]:
```
train_score = []
test_score = []
for i in range(1, 40):

        knn = KNeighborsClassifier(n_neighbors = i)
        knn.fit(X_train, y_train)
        pred_i = knn.predict(X_test)
        test_score.append(knn.score(X_test, y_test))
        train_score.append(knn.score(X_train, y_train))


plt.figure(figsize =(10, 8))

plt.plot(range(1, 40), test_score, color ='blue', linestyle ='dashed', marke


plt.plot(range(1, 40), train_score, color ='red', linestyle ='dashed', marke

plt.xlabel('K')
plt.legend(['test score', 'train score'], loc ='upper right')

print("Maximum test score:",max(test_score),"at K =",test_score.index(max(te
```

```
Maximum test score: 0.6197183098591549 at K = 17
```



In [48]:
```python
# k = 17
classifier = KNeighborsClassifier(n_neighbors = 17)
classifier.fit(X_train,y_train)
```

Out[48]:
```
▾ KNeighborsClassifier
KNeighborsClassifier(n_neighbors=17)
```

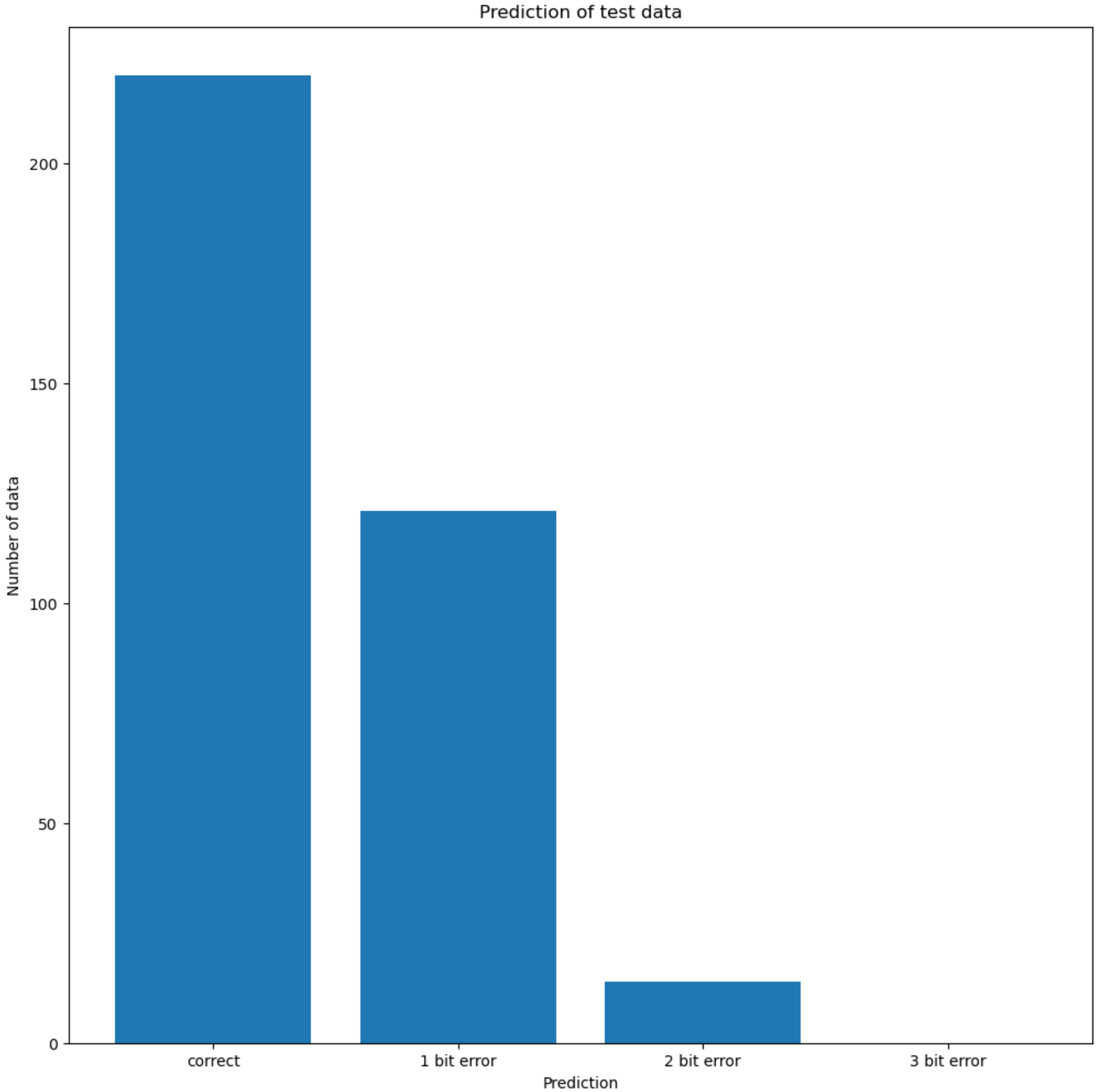
In [49]:
```python
#Predicting the ouput from input data (x_train) and (y_train)
y_pred1 = classifier.predict(X_train)
y_pred2 = classifier.predict(X_test)
```

In [50]:
```python
from sklearn.metrics import accuracy_score, mean_squared_error

print("train score",accuracy_score(y_train, y_pred1))
print("test score",accuracy_score(y_test, y_pred2))
print("MSE",mean_squared_error(y_test, y_pred2))

y_test = np.array(y_test)
```

```
train score 0.6287787182587666
test score 0.6197183098591549
MSE 0.49859154929577465
```

In [51]:
```python
# visualization
correct = 0
one_bit_error = 0
two_bit_error = 0
threemore_bit_error = 0
print('Shap of y_pred: ', y_test.shape)
for i in range(len(y_pred2)):
        if y_pred2[i] == y_test[i]:
                correct += 1
        elif abs(y_pred2[i] - y_test[i]) == 1:
                one_bit_error += 1
        elif abs(y_pred2[i] - y_test[i]) == 2:
                two_bit_error += 1
        else:
                threemore_bit_error += 1
plt.figure(figsize=(12, 12))
plt.bar(['correct', '1 bit error', '2 bit error', '3 bit error'], [correct,
plt.title('Prediction of test data')
plt.xlabel('Prediction')
plt.ylabel('Number of data')
plt.show()
```

```
Shap of y_pred:  (355,)
```



Prediction of test data
Number of data
Prediction
0
50
100
150
200
correct
1 bit error
2 bit error
3 bit error

In [51]: