In [12]:
```python
import pandas as pd
import numpy as np
from sklearn import datasets, linear_model
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
import random
import math
```

In [13]:
```python
# load data
data_frame = pd.read_csv('house_prices.csv')
feature_vectors = ['house age', 'distance to the nearest MRT station', 'number of convenience stores',
                   'house price of unit area']
data_frame
```

Out[13]:

	No	house age	distance to the nearest MRT station	number of convenience stores	house price of unit area
0	1	6.6	90.45606	9	58.1
1	2	20.5	2185.12800	3	25.6
2	3	30.0	1013.34100	5	22.8
3	4	12.9	250.63100	7	39.3
4	5	29.4	4510.35900	1	13.2
...	...	...	...	...	...
395	396	40.9	167.59890	5	41.0
396	397	31.7	5512.03800	1	18.8
397	398	8.0	132.54690	9	47.3
398	399	11.9	3171.32900	0	46.6
399	400	3.4	56.47425	7	54.4

400 rows × 5 columns

In [14]:
```python
feature_vectors
```

Out[14]:
```
['house age',
 'distance to the nearest MRT station',
 'number of convenience stores',
 'house price of unit area']
```

after loading all data we need, go on the first step: pre-processing data

step 1: pre-processing data

In [15]:
```python
# step 1: pre-processing data
# 3 features
data_house_age = data_frame[feature_vectors[0]]
data_distance_to_station = data_frame[feature_vectors[1]]
data_nb_of_stores = data_frame[feature_vectors[2]]

# 1 output
data_house_price = data_frame[feature_vectors[-1]]

# get normalized data
max_house_age = max(list(data_house_age))
min_house_age = min(list(data_house_age))
new_house_age = [((x - min_house_age) / (max_house_age - min_house_age))
                 for x in list(data_house_age)]

max_distance_to_station = max(list(data_distance_to_station))
min_distance_to_station = min(list(data_distance_to_station))
new_distance_to_station = [((x - min_distance_to_station) / (max_distance_to_station - min_distance_to_station))
                           for x in list(data_distance_to_station)]

max_nb_of_stores = max(list(data_nb_of_stores))
min_nb_of_stores = min(list(data_nb_of_stores))
new_nb_of_stores = [((x - min_nb_of_stores) / (max_nb_of_stores - min_nb_of_stores))
                    for x in list(data_nb_of_stores)]
```

step 2: Creating test and training set

In [16]:
```python
# step 2: Creating test and training set
# total data y
data_house_price_y = np.array(data_house_price).reshape(-1, 1)
# total data x for three features
data_house_age_x = np.array(new_house_age).reshape(-1, 1)
data_distance_to_station_x = np.array(new_distance_to_station).reshape(-1, 1)
data_nb_of_stores_x = np.array(new_nb_of_stores).reshape(-1, 1)
# split data to training data and test data
# shuffle == false <==> not random
train_data_house_age_x, test_data_house_age_x, train_data_house_price_y, test_data_house_price_y = \
    train_test_split(data_house_age_x, data_house_price_y, test_size=0.25, shuffle=False)
```

In order to compare with different features seperately, we create a function handling with step 3--step 5:

fuction:

Stochastic_gradient_decent

this function return:

1.theta[] after training

2.RMSE value we calculated

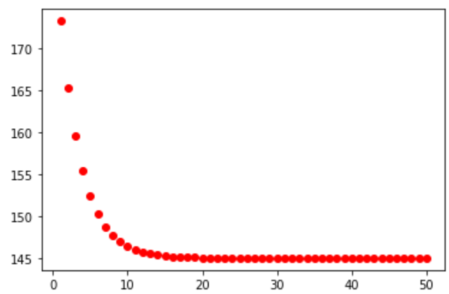
step 3 & 4 & 5: Stochastic gradient descent & Visualization & Evaluation

In [17]:
```
# step 3 & 4 & 5: Stochastic gradient descent & Visualization & Evaluation
def Stochastic_gradient_decent(train_data_feature_x, test_data_feature_x,
                               train_data_output_y, test_data_output_y):
    # step 3: Stochastic gradient descent
    loss_record = []  # record loss function value
    iter_record = []  # record iteration value
    training_len = len(train_data_feature_x)
    testing_len = len(test_data_feature_x)
    max_iteration = 50
    alpha = 0.01  # learning rate
    theta = [-1, -0.5]  # θ coefficients
    iter_count = 0

    # for every iteration
    while iter_count < max_iteration:
        loss = 0
        # algorithmn body
        for i in range(training_len):
            predicted_fuc = theta[0] * 1 + theta[1] * train_data_feature_x[i][0]
            theta[0] = theta[0] + alpha * (train_data_output_y[i][0] - predicted_fuc) * 1
            theta[1] = theta[1] + alpha * (train_data_output_y[i][0] - predicted_fuc) * train_data_feature_x[i][0]
        # calculate J(theta) cost fuction
        for j in range(training_len):
            predicted_fuc = theta[0] * 1 + theta[1] * train_data_feature_x[j][0]
            error = (train_data_output_y[j][0] - predicted_fuc) ** 2
            loss = loss + error
        loss = (1 / training_len) * loss
        iter_count += 1
        loss_record.append(loss)
        iter_record.append(iter_count)

    # step 4: Visualization
    iter_x = np.array(iter_record).reshape(-1, 1)
    loss_y = np.array(loss_record).reshape(-1, 1)
    # model = linear_model.LinearRegression()
    # model.fit(iter_x, loss_y)
    # predicted_y = model.predict(iter_x)
    plt.scatter(iter_x, loss_y, color="red")
    plt.show()

    # step 5: Evaluation
    # compute RMSE for training set
    total_sum_training_set = 0
    for i in range(training_len):
        predicted_fuc = theta[0] * 1 + theta[1] * train_data_feature_x[i][0]
        temp_sum = (train_data_output_y[i][0] - predicted_fuc) ** 2
        total_sum_training_set += temp_sum
    RMSE_training = math.sqrt(total_sum_training_set / training_len)

    # compute RMSE for training set
    total_sum_testing_set = 0
    for i in range(testing_len):
        predicted_fuc = theta[0] * 1 + theta[1] * test_data_feature_x[i][0]
        temp_sum = (test_data_output_y[i][0] - predicted_fuc) ** 2
        total_sum_testing_set += temp_sum
    RMSE_testing = math.sqrt(total_sum_testing_set / testing_len)

    return theta, RMSE_training, RMSE_testing
```

for the first feature: house_age

we get the theta[0] and theta[1], and also, RMSE for both training data set and testing data set;

In [18]:
```
 # step 3 & 4 & 5: Stochastic gradient descent & Visualization & Evaluation
feature = feature_vectors[0]
theta_house_age_model, RMSE_training_house_age, RMSE_testing_house_age = \
    Stochastic_gradient_decent(train_data_house_age_x, test_data_house_age_x,
                               train_data_house_price_y, test_data_house_price_y)
print("RMSE for", feature, "training data set is : ", RMSE_training_house_age)
print("RMSE for", feature, "testing data set is : ", RMSE_testing_house_age)
print("theta for", feature, "is : ", "theta[0] : ", theta_house_age_model[0], "theta[1] : ",
      theta_house_age_model[1])
print()
```



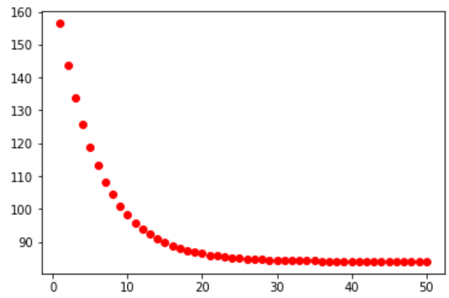

```
RMSE for house age training data set is :  12.045510305912353
RMSE for house age testing data set is :  16.58731450340051
theta for house age is :  theta[0] :  42.54078538346594 theta[1] :  -10.319399022339129
```

Then, we compute the other two features:

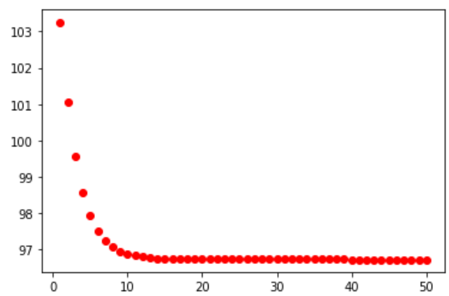
which are 'distance to the nearest MRT station' and 'number of convenience stores';

and compute corresponding theta[] and RMSE value;

In [19]:
```
# step 6: Repeating for the other two features
# for feature distance
feature = feature_vectors[1]
train_data_distance_x, test_data_distance_x, train_data_house_price_y, test_data_house_price_y = \
    train_test_split(data_distance_to_station_x, data_house_price_y, test_size=0.25, shuffle=False)
theta_distance_model, RMSE_training_distance, RMSE_testing_distance = \
    Stochastic_gradient_decent(train_data_distance_x, test_data_distance_x,
                               train_data_house_price_y, test_data_house_price_y)
print("RMSE for", feature, "training data set is : ", RMSE_training_distance)
print("RMSE for", feature, "testing data set is : ", RMSE_testing_distance)
print("theta for", feature, "is : ", "theta[0] : ", theta_distance_model[0], "theta[1] : ",
      theta_distance_model[1])
print()

 # for feature number of stores
feature = feature_vectors[2]
train_data_nb_store_x, test_data_nb_store_x, train_data_house_price_y, test_data_house_price_y = \
    train_test_split(data_nb_of_stores_x, data_house_price_y, test_size=0.25, shuffle=False)
theta_nb_store_model, RMSE_training_nb_store, RMSE_testing_nb_store = \
    Stochastic_gradient_decent(train_data_nb_store_x, test_data_nb_store_x,
                               train_data_house_price_y, test_data_house_price_y)
print("RMSE for", feature, "training data set is : ", RMSE_training_nb_store)
print("RMSE for", feature, "testing data set is : ", RMSE_testing_nb_store)
print("theta for", feature, "is : ", "theta[0] : ", theta_nb_store_model[0], "theta[1] : ",
      theta_nb_store_model[1])
print()
```




```
RMSE for distance to the nearest MRT station training data set is :  9.165754538401488
RMSE for distance to the nearest MRT station testing data set is :  12.652088009723935
theta for distance to the nearest MRT station is :  theta[0] :  44.766087037899375 theta[1] :  -46.500633970906314
```




```
RMSE for number of convenience stores training data set is :  9.83487827563954
RMSE for number of convenience stores testing data set is :  14.731993508206784
theta for number of convenience stores is :  theta[0] :  27.486676129636784 theta[1] :  25.642117651334722
```

In [17]:
```
# step 7: bonus compare
RMSE_training_dict = {feature_vectors[0]: RMSE_training_house_age,
                      feature_vectors[1]: RMSE_training_distance,
                      feature_vectors[2]: RMSE_training_nb_store, }
RMSE_testing_dict = {feature_vectors[0]: RMSE_testing_house_age,
                     feature_vectors[1]: RMSE_testing_distance,
                     feature_vectors[2]: RMSE_testing_nb_store, }
result_train = sorted(RMSE_training_dict.items(), key=lambda item: item[1])
result_test = sorted(RMSE_testing_dict.items(), key=lambda item: item[1])
print(result_train)
print(result_test)
```

```
[('distance to the nearest MRT station', 9.165754538401488), ('number of convenience stores', 9.165754538401488), ('house age',
12.045510305912353)]
[('distance to the nearest MRT station', 12.652088009723935), ('number of convenience stores', 12.652088009723935), ('house ag
e', 16.58731450340051)]
```

As we can see, this time we get all this three RMSE for our data sets;

this respectively is:

RMSE for house age training data set is : 25.230370617579414

RMSE for house age testing data set is : 29.062757171534063

RMSE for distance to the nearest MRT station training data set is : 26.437983293073824

RMSE for distance to the nearest MRT station testing data set is : 30.0561440633274

RMSE for number of convenience stores training data set is : 25.87887184864255

RMSE for number of convenience stores testing data set is : 29.536341013282314

and clearly:

25.230 < 25.878 < 26.437

29.062 < 29.536 < 30.056

after this time training, we can rank all three models according to RMSE:

the performance of model_1 > model_3 > model_2;

As we use Stochastic gradient descent algorithmn for this report, the results are random. the data above is generated by some training process.

So finally, we give code for comparation as following:

In [ ]: