In [51]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from statsmodels.tsa.arima_model import ARIMA
from sklearn.metrics import mean_squared_error
import seaborn as sns
import warnings
from joblib import Parallel, delayed
import seaborn as sns

# Set the style for the plots
sns.set(style="whitegrid")

warnings.filterwarnings('ignore')
```

In [5]:
```
train_df = pd.read_csv("C:/Users/dhanu/OneDrive/train.csv")
test_df = pd.read_csv("C:/Users/dhanu/OneDrive/test.csv")

# Display the first few rows of the datasets
train_df.head(), test_df.head()
```

Out[5]:

```
(                     ID        date     Item Id  \
 0  2022-04-12_B09KDTS4DC  2022-04-12  B09KDTS4DC
 1  2022-04-12_B09MR2MLZH  2022-04-12  B09MR2MLZH
 2  2022-04-12_B09KSYL73R  2022-04-12  B09KSYL73R
 3  2022-04-12_B09KT5HMNY  2022-04-12  B09KT5HMNY
 4  2022-04-12_B09KTF8ZDQ  2022-04-12  B09KTF8ZDQ

                                           Item Name  ad_spend anarix_id
\
 0  NapQueen Elizabeth 8" Gel Memory Foam Mattress...       NaN  NAPQUEEN
 1  NapQueen 12 Inch Bamboo Charcoal Queen Size Me...       NaN  NAPQUEEN
 2     NapQueen Elsa 8" Innerspring Mattress, Twin XL       NaN  NAPQUEEN
 3        NapQueen Elsa 6" Innerspring Mattress, Twin       NaN  NAPQUEEN
 4     NapQueen Elsa 6" Innerspring Mattress, Twin XL       NaN  NAPQUEEN

    units  unit_price
 0    0.0         0.0
 1    0.0         0.0
 2    0.0         0.0
 3    0.0         0.0
 4    0.0         0.0  ,
                     ID        date     Item Id  \
 0  2024-07-01_B09KDR64LT  2024-07-01  B09KDR64LT
 1  2024-07-01_B09KDTS4DC  2024-07-01  B09KDTS4DC
 2  2024-07-01_B09KDTHJ6V  2024-07-01  B09KDTHJ6V
 3  2024-07-01_B09KDQ2BWY  2024-07-01  B09KDQ2BWY
 4  2024-07-01_B09KDYY3SB  2024-07-01  B09KDYY3SB

                                           Item Name  ad_spend anarix_id
\
 0  NapQueen Elizabeth 10" Gel Memory Foam Mattres...       NaN  NAPQUEEN
 1  NapQueen Elizabeth 8" Gel Memory Foam Mattress...       NaN  NAPQUEEN
 2  NapQueen Elizabeth 12" Gel Memory Foam Mattres...       NaN  NAPQUEEN
 3  NapQueen Elizabeth 12" Gel Memory Foam Mattres...       NaN  NAPQUEEN
 4  NapQueen Elizabeth 10" Gel Memory Foam Mattres...    101.72  NAPQUEEN

    unit_price
 0         0.0
 1         0.0
 2         0.0
 3         0.0
 4      1094.5  )
```

In [7]:
```
#EDA-Exploratory Data Analysis

# Checking for missing values in the training dataset
missing_values_train = train_df.isnull().sum()

# Summary statistics of the training dataset
summary_statistics_train = train_df.describe(include='all')

# Checking the data types of each column in the training dataset
data_types_train = train_df.dtypes

print(missing_values_train)
print(summary_statistics_train)
print(data_types_train)
```

```
ID                0
date              0
Item Id           2
Item Name      1832
ad_spend      24187
anarix_id         0
units         17898
unit_price        0
dtype: int64
                            ID        date     Item Id  \
count                   101490      101490      101488
unique                  101490         781         217
top     2022-04-12_B09KDTS4DC  2023-03-09  B09MR2FY5D
freq                         1         189         781
mean                       NaN         NaN         NaN
std                        NaN         NaN         NaN
min                        NaN         NaN         NaN
25%                        NaN         NaN         NaN
50%                        NaN         NaN         NaN
75%                        NaN         NaN         NaN
max                        NaN         NaN         NaN

                                                 Item Name      ad_spend
\
count                                                99658  77303.000000
unique                                                 199           NaN
top     NapQueen Margaret 8" Charcoal Memory Foam Matt...           NaN
freq                                                   781           NaN
mean                                                   NaN    110.771470
std                                                    NaN    529.303777
min                                                    NaN      0.000000
25%                                                    NaN      0.000000
50%                                                    NaN      4.230000
75%                                                    NaN     44.310000
max                                                    NaN  47934.990000

       anarix_id         units     unit_price
count     101490  83592.000000  101490.000000
unique         1           NaN            NaN
top     NAPQUEEN           NaN            NaN
freq      101490           NaN            NaN
mean         NaN     10.284381     106.750922
std          NaN     68.945915     425.704733
min          NaN   -173.000000   -8232.000000
25%          NaN      0.000000       0.000000
50%          NaN      1.000000       0.000000
75%          NaN      5.000000       0.000000
max          NaN   9004.000000   21557.390000
ID            object
date          object
Item Id       object
Item Name     object
ad_spend     float64
anarix_id     object
units        float64
unit_price   float64
dtype: object
```

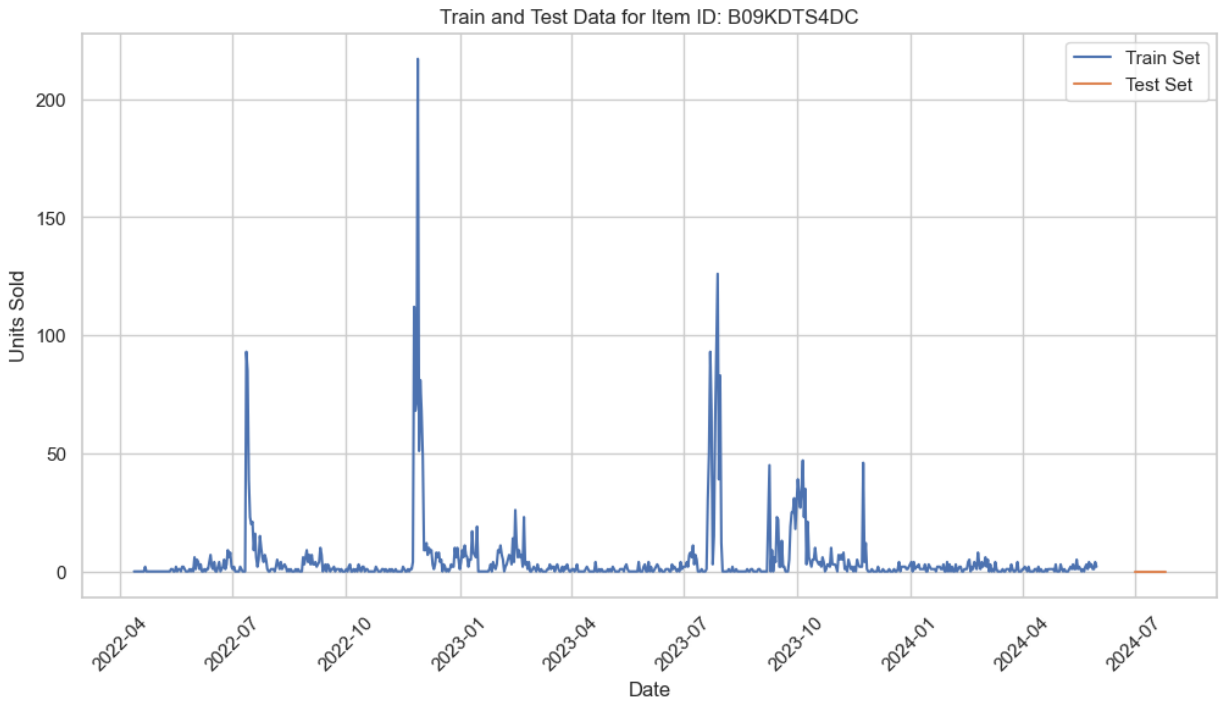
In [9]:
```
# Handle missing values in 'units' by filling with 0
train_df['units'].fillna(0, inplace=True)

# Replace negative values in 'units' with NaN and then fill with 0
train_df.loc[train_df['units'] < 0, 'units'] = None
train_df['units'].fillna(0, inplace=True)

# Replace negative values in 'unit_price' with absolute values
train_df['unit_price'] = train_df['unit_price'].abs()

# Convert 'date' column to datetime format and create new features
train_df['date'] = pd.to_datetime(train_df['date'])
train_df['year'] = train_df['date'].dt.year
train_df['month'] = train_df['date'].dt.month
train_df['day'] = train_df['date'].dt.day
train_df['day_of_week'] = train_df['date'].dt.dayofweek

# Convert 'date' column to datetime format and create new features in the
test_df['date'] = pd.to_datetime(test_df['date'])
test_df['year'] = test_df['date'].dt.year
test_df['month'] = test_df['date'].dt.month
test_df['day'] = test_df['date'].dt.day
test_df['day_of_week'] = test_df['date'].dt.dayofweek

print(test_df.head())
print(train_df.head())
```

```
                      ID       date     Item Id  \
0  2024-07-01_B09KDR64LT 2024-07-01  B09KDR64LT
1  2024-07-01_B09KDTS4DC 2024-07-01  B09KDTS4DC
2  2024-07-01_B09KDTHJ6V 2024-07-01  B09KDTHJ6V
3  2024-07-01_B09KDQ2BWY 2024-07-01  B09KDQ2BWY
4  2024-07-01_B09KDYY3SB 2024-07-01  B09KDYY3SB

                                          Item Name  ad_spend anarix_id
\
0  NapQueen Elizabeth 10" Gel Memory Foam Mattres...       NaN  NAPQUEEN
1  NapQueen Elizabeth 8" Gel Memory Foam Mattress...       NaN  NAPQUEEN
2  NapQueen Elizabeth 12" Gel Memory Foam Mattres...       NaN  NAPQUEEN
3  NapQueen Elizabeth 12" Gel Memory Foam Mattres...       NaN  NAPQUEEN
4  NapQueen Elizabeth 10" Gel Memory Foam Mattres...    101.72  NAPQUEEN

   unit_price  year  month  day  day_of_week
0         0.0  2024      7    1            0
1         0.0  2024      7    1            0
2         0.0  2024      7    1            0
3         0.0  2024      7    1            0
4      1094.5  2024      7    1            0
                      ID       date     Item Id  \
0  2022-04-12_B09KDTS4DC 2022-04-12  B09KDTS4DC
1  2022-04-12_B09MR2MLZH 2022-04-12  B09MR2MLZH
2  2022-04-12_B09KSYL73R 2022-04-12  B09KSYL73R
3  2022-04-12_B09KT5HMNY 2022-04-12  B09KT5HMNY
4  2022-04-12_B09KTF8ZDQ 2022-04-12  B09KTF8ZDQ

                                          Item Name  ad_spend anarix_id
\
0  NapQueen Elizabeth 8" Gel Memory Foam Mattress...       NaN  NAPQUEEN
1  NapQueen 12 Inch Bamboo Charcoal Queen Size Me...       NaN  NAPQUEEN
2     NapQueen Elsa 8" Innerspring Mattress, Twin XL       NaN  NAPQUEEN
3        NapQueen Elsa 6" Innerspring Mattress, Twin       NaN  NAPQUEEN
4     NapQueen Elsa 6" Innerspring Mattress, Twin XL       NaN  NAPQUEEN

   units  unit_price  year  month  day  day_of_week
0    0.0         0.0  2022      4   12            1
1    0.0         0.0  2022      4   12            1
2    0.0         0.0  2022      4   12            1
3    0.0         0.0  2022      4   12            1
4    0.0         0.0  2022      4   12            1
```

In [11]:

```
item_id = 'B09KDTS4DC'  # Replace with the Item Id you want to visualize

# Filter the data for the selected Item Id
item_train_df = train_df[train_df['Item Id'] == item_id]
item_test_df = test_df[test_df['Item Id'] == item_id]
```

In [13]:
```
# Ensure that the date columns are in datetime format
item_train_df['date'] = pd.to_datetime(item_train_df['date'])
item_test_df['date'] = pd.to_datetime(item_test_df['date'])

# Plotting train and test data separately
plt.figure(figsize=(12, 6))
plt.plot(item_train_df['date'], item_train_df['units'], label='Train Set'
plt.plot(item_test_df['date'], item_test_df['unit_price'], label='Test Se
plt.title(f'Train and Test Data for Item ID: {item_id}')
plt.xlabel('Date')
plt.ylabel('Units Sold')
plt.legend()
plt.xticks(rotation=45)
plt.show()
```



In [14]:
```
# Group data by 'Item Id' and 'date' for time series analysis
item_sales = train_df.groupby(['date', 'Item Id']).agg({'units': 'sum'}).

# Pivot table to create a time series for each item
time_series_data = item_sales.pivot(index='date', columns='Item Id', valu

# Initialize dictionary to store ARIMA predictions
arima_predictions = {}
```

In [17]:
```
# Convert 'date' to datetime if it's not already
train_df['date'] = pd.to_datetime(train_df['date'])
test_df['date'] = pd.to_datetime(test_df['date'])

# Extract date features
train_df['year'] = train_df['date'].dt.year
train_df['month'] = train_df['date'].dt.month
train_df['day'] = train_df['date'].dt.day
train_df['day_of_week'] = train_df['date'].dt.dayofweek

test_df['year'] = test_df['date'].dt.year
test_df['month'] = test_df['date'].dt.month
test_df['day'] = test_df['date'].dt.day
test_df['day_of_week'] = test_df['date'].dt.dayofweek
```

In [19]:
```
# Create lag features for the 'units' column
lag_days = [1, 7, 14]  # Example lags: 1 day, 1 week, 2 weeks

for lag in lag_days:
    train_df[f'units_lag_{lag}'] = train_df.groupby('Item Id')['units'].s
    test_df[f'units_lag_{lag}'] = test_df.groupby('Item Id')['unit_price'
```

In [21]:
```
# Create rolling window features for the 'units' column
window_sizes = [3, 7, 14]  # Example windows: 3 days, 1 week, 2 weeks

for window in window_sizes:
    train_df[f'units_roll_mean_{window}'] = train_df.groupby('Item Id')['
    test_df[f'units_roll_mean_{window}'] = test_df.groupby('Item Id')['un
```

In [23]:
```
# Interaction between ad spend and units
train_df['ad_spend_units'] = train_df['ad_spend'] * train_df['units']
test_df['ad_spend_units'] = test_df['ad_spend'] * test_df['unit_price']
```

In [25]:
```
# Fill NaN values after creating lag and rolling features
train_df.fillna(0, inplace=True)
test_df.fillna(0, inplace=True)
```

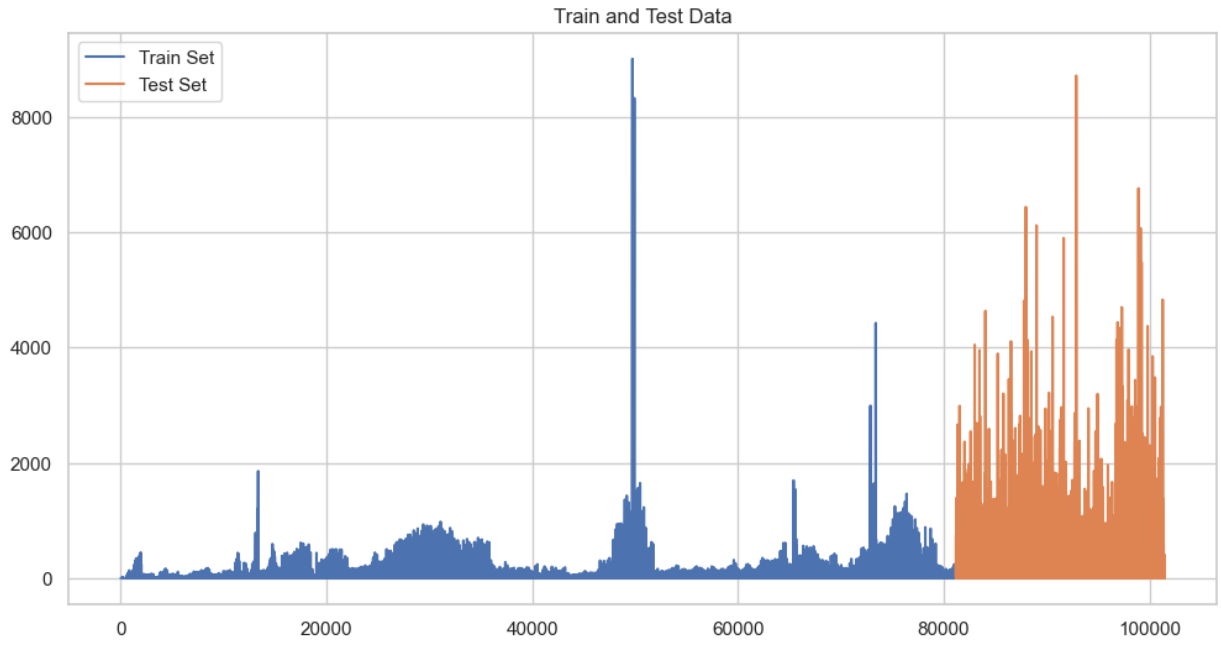
In [27]:
```
# Display the first few rows to check the new features
print(train_df.head())
print(test_df.head())
```

```
                      ID       date     Item Id  \
0  2022-04-12_B09KDTS4DC 2022-04-12  B09KDTS4DC
1  2022-04-12_B09MR2MLZH 2022-04-12  B09MR2MLZH
2  2022-04-12_B09KSYL73R 2022-04-12  B09KSYL73R
3  2022-04-12_B09KT5HMNY 2022-04-12  B09KT5HMNY
4  2022-04-12_B09KTF8ZDQ 2022-04-12  B09KTF8ZDQ

                                          Item Name  ad_spend anarix_id
\
0  NapQueen Elizabeth 8" Gel Memory Foam Mattress...       0.0  NAPQUEEN
1  NapQueen 12 Inch Bamboo Charcoal Queen Size Me...       0.0  NAPQUEEN
2     NapQueen Elsa 8" Innerspring Mattress, Twin XL       0.0  NAPQUEEN
3        NapQueen Elsa 6" Innerspring Mattress, Twin       0.0  NAPQUEEN
```

```
4     NapQueen Elsa 6" Innerspring Mattress, Twin XL       0.0  NAPQUEEN

   units  unit_price  year  month  day  day_of_week  units_lag_1  units_l
ag_7  \
0    0.0         0.0  2022      4   12            1          0.0
0.0
1    0.0         0.0  2022      4   12            1          0.0
0.0
2    0.0         0.0  2022      4   12            1          0.0
0.0
3    0.0         0.0  2022      4   12            1          0.0
0.0
4    0.0         0.0  2022      4   12            1          0.0
0.0

   units_lag_14  units_roll_mean_3  units_roll_mean_7  units_roll_mean_14
\
0           0.0                0.0                0.0                 0.0
1           0.0                0.0                0.0                 0.0
2           0.0                0.0                0.0                 0.0
3           0.0                0.0                0.0                 0.0
4           0.0                0.0                0.0                 0.0

   ad_spend_units
0             0.0
1             0.0
2             0.0
3             0.0
4             0.0
                     ID       date     Item Id  \
0  2024-07-01_B09KDR64LT 2024-07-01  B09KDR64LT
1  2024-07-01_B09KDTS4DC 2024-07-01  B09KDTS4DC
2  2024-07-01_B09KDTHJ6V 2024-07-01  B09KDTHJ6V
3  2024-07-01_B09KDQ2BWY 2024-07-01  B09KDQ2BWY
4  2024-07-01_B09KDYY3SB 2024-07-01  B09KDYY3SB

                                          Item Name  ad_spend anarix_id
\
0  NapQueen Elizabeth 10" Gel Memory Foam Mattres...      0.00  NAPQUEEN
1  NapQueen Elizabeth 8" Gel Memory Foam Mattress...      0.00  NAPQUEEN
2  NapQueen Elizabeth 12" Gel Memory Foam Mattres...      0.00  NAPQUEEN
3  NapQueen Elizabeth 12" Gel Memory Foam Mattres...      0.00  NAPQUEEN
4  NapQueen Elizabeth 10" Gel Memory Foam Mattres...    101.72  NAPQUEEN

   unit_price  year  month  day  day_of_week  units_lag_1  units_lag_7  \
0         0.0  2024      7    1            0          0.0          0.0
1         0.0  2024      7    1            0          0.0          0.0
2         0.0  2024      7    1            0          0.0          0.0
3         0.0  2024      7    1            0          0.0          0.0
4      1094.5  2024      7    1            0          0.0          0.0

   units_lag_14  units_roll_mean_3  units_roll_mean_7  units_roll_mean_14
\
0           0.0                0.0                0.0                 0.0
1           0.0                0.0                0.0                 0.0
2           0.0                0.0                0.0                 0.0
3           0.0                0.0                0.0                 0.0
```

```
4            0.0                0.0                0.0                0.0

   ad_spend_units
0            0.00
1            0.00
2            0.00
3            0.00
4       111332.54
```

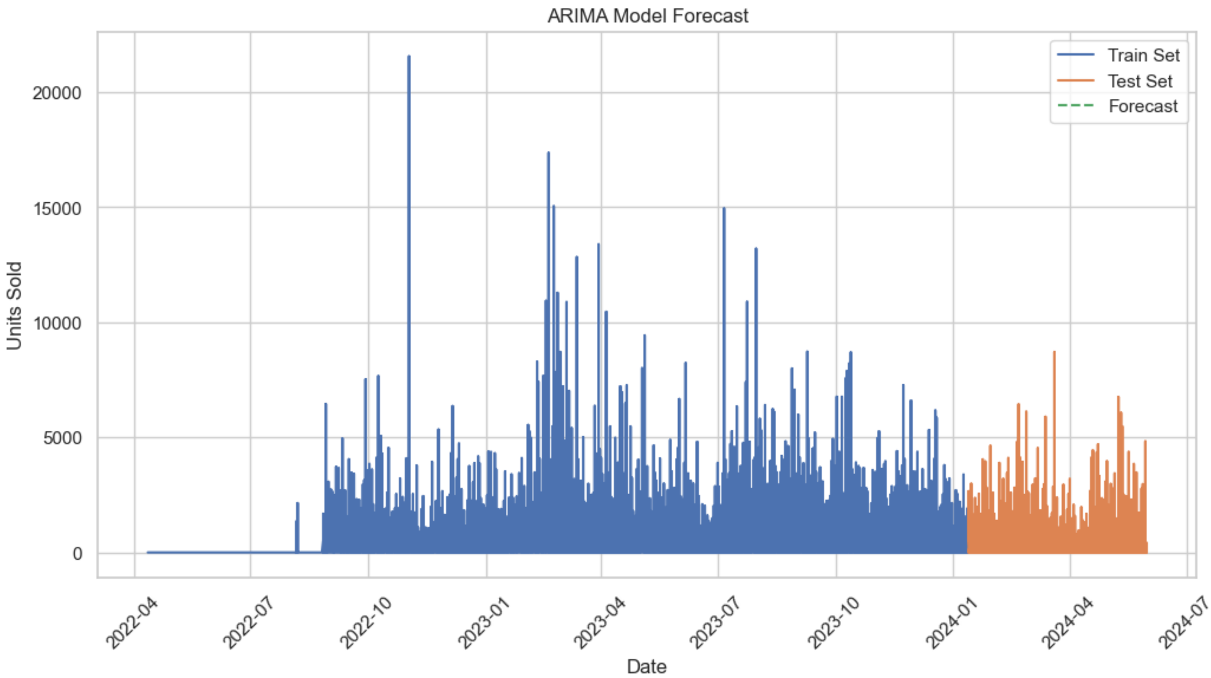
In [29]:
```
# Assuming `data` is already loaded and combined as shown in the previous
train_size = int(len(train_df) * 0.8)
train, test = train_df.iloc[:train_size], train_df.iloc[train_size:]

# Plot the train and test sets
plt.figure(figsize=(12, 6))
plt.plot(train.index, train['units'], label='Train Set')
plt.plot(test.index, test['unit_price'], label='Test Set')
plt.legend()
plt.title('Train and Test Data')
plt.show()
```



In [37]:
```
def fit_arima_model(item_id, item_series):
    # Ensure that the series has enough data points
    if len(item_series) < 30:  # Adjust the threshold as necessary
        print(f'Item ID: {item_id} has too few data points, skipping...')
        return item_id, None, None

    # Split the data into training and testing sets (80-20 split)
    train_size = int(len(item_series) * 0.8)
    train_data, test_data = item_series[:train_size], item_series[train_s

    # Automatically select the best ARIMA model using auto_arima
    try:
        model = auto_arima(train_data, seasonal=False, stepwise=True, sup
                           error_action='ignore', trace=False)
        model_fit = model.fit(train_data)

        # Forecast the future values
        forecast = model_fit.predict(n_periods=len(test_data))

        # Calculate MSE for the forecast
        mse = mean_squared_error(test_data, forecast)
        print(f'Item ID: {item_id}, Best ARIMA Order: {model.order}, MSE:

        return item_id, forecast, mse

    except Exception as e:
        print(f'Item ID: {item_id} encountered an error: {e}')
        return item_id, None, None
```

In [41]:
```
from statsmodels.tsa.arima.model import ARIMA
from sklearn.metrics import mean_squared_error
import numpy as np

# Select the target column
target_column = 'unit_price'
train_data = train_df.set_index('date')[target_column]
test_data = test_df.set_index('date')[target_column]

# Split the data (assuming 'date' is the index)
train_size = int(len(train_data) * 0.8)
train_set, test_set = train_data[:train_size], train_data[train_size:]

# Define the ARIMA model parameters (p, d, q) - replace with your best pa
p, d, q = 1, 1, 1  # Example values, adjust according to your model selec
arima_model = ARIMA(train_set, order=(p, d, q))

# Fit the ARIMA model
arima_model_fit = arima_model.fit()



# Make predictions on the test set
forecast_steps = len(test_set)
forecast = arima_model_fit.forecast(steps=forecast_steps)

# Create a DataFrame for the forecast
forecast_index = test_set.index
forecast_df = pd.DataFrame(data=forecast, index=forecast_index, columns=[

# Plot actual vs predicted values
plt.figure(figsize=(12, 6))
plt.plot(train_set.index, train_set, label='Train Set')
plt.plot(test_set.index, test_set, label='Test Set')
plt.plot(forecast_df.index, forecast_df['Forecast'], label='Forecast', li
plt.legend()
plt.title('ARIMA Model Forecast')
plt.xlabel('Date')
plt.ylabel('Units Sold')
plt.xticks(rotation=45)
plt.show()

# Calculate and print the Mean Squared Error (MSE) of the forecast
mse = mean_squared_error(test_set, forecast)
print(f'Mean Squared Error: {mse:.2f}')
```

```
C:\Users\dhanu\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_mode
l.py:473: ValueWarning: A date index has been provided, but it has no ass
ociated frequency information and so will be ignored when e.g. forecastin
g.
  self._init_dates(dates, freq)
C:\Users\dhanu\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_mode
l.py:473: ValueWarning: A date index has been provided, but it has no ass
ociated frequency information and so will be ignored when e.g. forecastin
g.
  self._init_dates(dates, freq)
C:\Users\dhanu\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_mode
l.py:473: ValueWarning: A date index has been provided, but it has no ass
ociated frequency information and so will be ignored when e.g. forecastin
g.
  self._init_dates(dates, freq)
C:\Users\dhanu\anaconda3\Lib\site-packages\statsmodels\tsa\base\tsa_mode
l.py:836: ValueWarning: No supported index is available. Prediction resul
ts will be given with an integer index beginning at `start`.
  return get_prediction_index(
```




```
Mean Squared Error: 111288.14
```

In [ ]: